

CIVIL-MILITARY PREPREDNESS FOR AN ELECTROMAGNETIC PULSE CATASTROPHE

OFFICIAL CONSENSUS

A Surfeit of Studies

The natural and nuclear EMP threats described in the previous chapter, though still unknown or little understood by many policymakers and the public are not controversial as constituting threats to the very existence of modern civilization, threats that urgently need to be addressed by public policy. Not counting the present study, two Congressional Commissions and three U.S. Government sponsored projects have produced five major independent studies--all acknowledging that EMP is an existential threat to modern society and generally endorsing urgent implementation of the EMP Commission's recommendations.

Not one official study by the U.S. Government or by any Congressional Commission dissents from the above consensus.

A brief review of the several Commission and U.S. Government reports on EMP, even at the risk of some redundancy, is well worthwhile for most policymakers and the average citizen. Skeptics and even devout cynics may be moved by reading, over and over again, the words of successive independent studies, each re-examining the evidence with a different team of experts, and each arriving at the same conclusion about the EMP threat independently. These five studies also deserve some attention on their own merit, as each one represents an enormous investment of U.S. Government expertise and resources, each the collective product of different teams of scientists, technicians, strategists and other experts, each supported by different departments and agencies and laboratories. This chapter shall briefly review:

- The EMP Commission Reports
- The National Academy of Sciences Report
- The Strategic Posture Commission Report
- The NERC-DOE Report
- The FERC Interagency Report

The reader should be mindful that typically major public policy decisions are made and major programs enacted based on the recommendations of a *single* Congressional Commission or U.S. Government study of the gravity of any *one* of the reports listed above. Perhaps after the review below the reader may come to share the view of Commissioner Cheryl LaFleur, of the Federal Energy Regulatory Commission, who at the International Electric Infrastructure Summit, held in Washington D.C. on April 11, 2011, publicly declared, "We have done enough studies. It is time to act!"

The EMP Commission Reports

In 2001 the Congress established the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack. The EMP Commission Chairman was Dr. William R. Graham. Graham served as Science Advisor to President Reagan, Administrator of NASA, and is one of the scientists who first discovered the EMP effect during the STARFISH PRIME nuclear test in 1962. Dr. Graham is widely regarded as one of America's best scientific minds and the Free World's foremost expert on EMP. Other EMP Commissioners were equally distinguished, like Dr. John Foster, who designed many of the U.S. nuclear warheads currently operational, and Dr. Lowell Wood, the successor to H-Bomb inventor Dr. Edward Teller at Lawrence Livermore National Laboratory. The EMP Commission was empowered by Congress to command all the scientific, technical, intelligence and strategic expertise at all the departments, agencies, and national laboratories of the U.S. Government.⁵⁴

For eight years, 2001-2008, the EMP Commission analyzed the threat and developed a plan to protect U.S. military forces and civilian critical infrastructures, producing numerous classified and unclassified reports and staff papers. The EMP Commission delivered two major unclassified reports to Congress one in 2004 and the other in 2008. The 2004 *Executive Report* summarizes the EMP Commission's views on the EMP threat and how to protect U.S. military forces and civilian critical infrastructures generally. The 2008 EMP Commission report, *Critical National Infrastructures*, provides a much more detailed treatment of the EMP threat to critical infrastructures and how to protect them.⁵⁵

The *Executive Report* offers an "Abstract" briefly summarizing the EMP Commission's findings that virtually any determined adversary can achieve an EMP attack capability against the U.S., that EMP is in a small category of existential threats to our civilization, that U.S. vulnerability to EMP is "increasing daily" but, "Correction is...well within the Nation's means and resources to accomplish." The *Executive Report*:

Several potential adversaries have or can acquire the capability to attack the United States with a high-altitude nuclear weapon-generated electromagnetic pulse (EMP). A determined adversary can achieve an EMP attack capability without having a high level of sophistication.

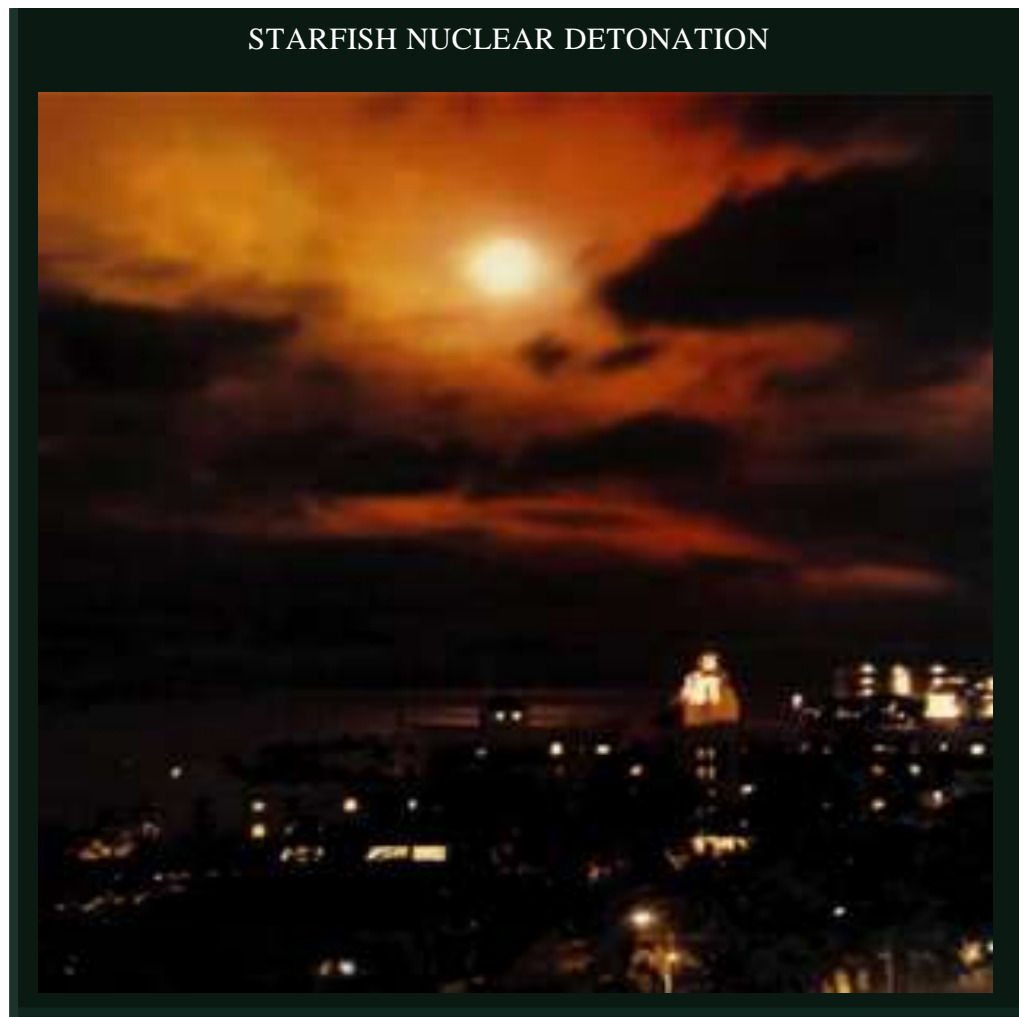
EMP is one of a small number of threats that can hold our society at risk of catastrophic consequences. EMP will cover the wide geographic region within line of sight to the nuclear weapon. It has the capability to produce significant damage to critical infrastructures and thus to the very fabric of U.S. society, as well as to the ability of the United States and Western nations to project influence and military power.

⁵⁴ EMP Commission, *Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack*, Volume I: Executive Report (Washington, D.C.: 2004), pp.B-1-B-3.

⁵⁵ Ibid; EMP Commission, *Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack: Critical National Infrastructures* (Washington, D.C.: 2008).

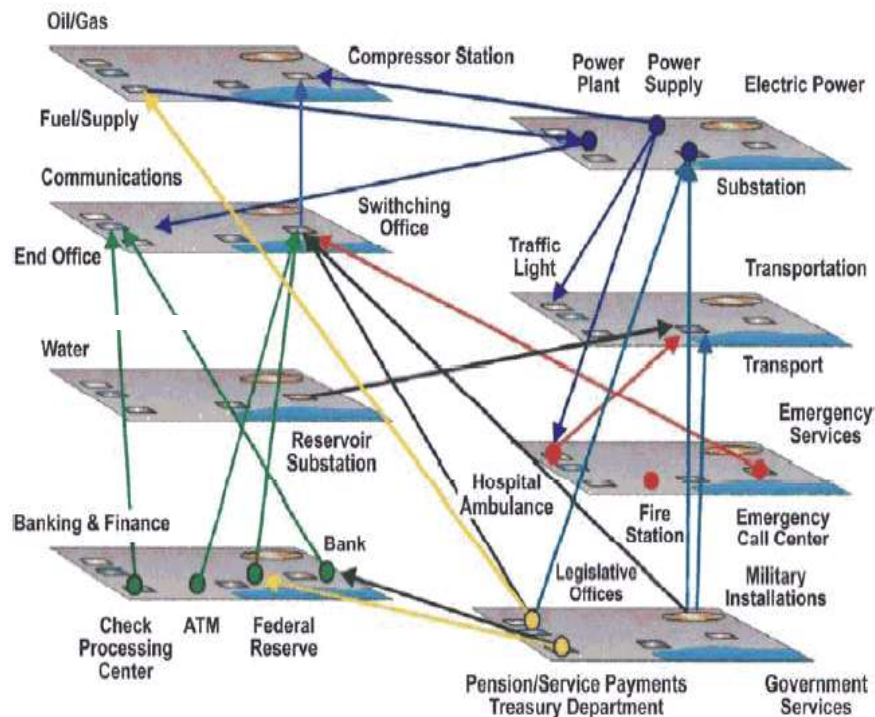
The common element that can produce such an impact from EMP is primarily electronics, so pervasive in all aspects of our society and military, coupled through critical infrastructures. Our vulnerability is increasing daily as our use of and dependence on electronics continues to grow. The impact of EMP is asymmetric in relation to potential protagonists who are not as dependent on modern electronics.

The current vulnerability of our critical infrastructures can both invite and reward attack if not corrected. Correction is feasible and well within the Nation's means and resources to accomplish.⁵



The July 1962 high altitude nuclear test where the U.S. first discovered the EMP phenomenon, aurora effects resulting from the nuclear burst as viewed from Honolulu 900 miles distant. (Source: EMP Commission, *Executive Report*, p. 5.)

⁵⁶ Ibid Executive Report, p. v.



The critical infrastructures rely on each other for their operations. Electric power is the "keystone" among critical infrastructures, most essential for all their operations, and indispensable to their recovery from an EMP event. (Source: EMP Commission, *Executive Report*, p. 9.)

The EMP Commission's *Executive Report* warns that an EMP event could inflict an unprecedented catastrophe threatening the "overall viability of our Nation" and have "irreversible effects on the country's ability to support its population." The *Executive Report*:

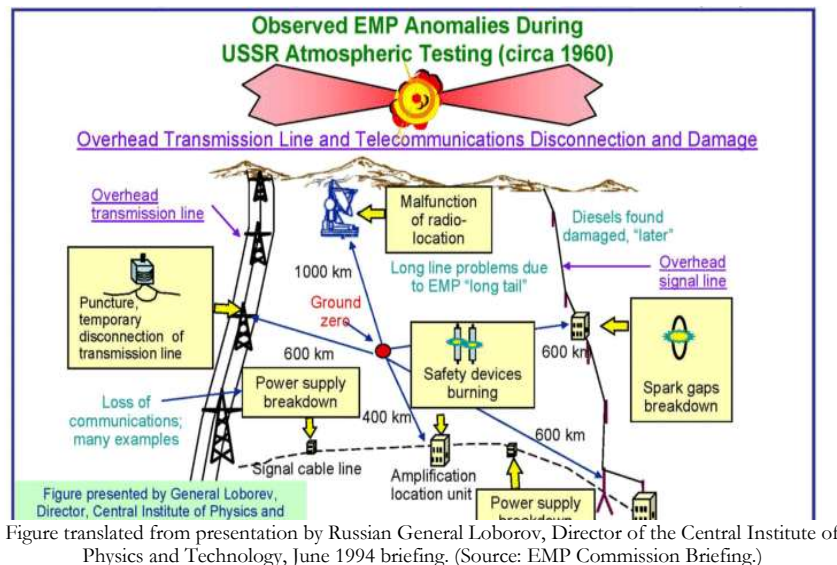
Depending on the specific characteristics of the attacks, unprecedented cascading failures of our major infrastructures could result. In that event, a regional or national recovery would be long and difficult and would seriously degrade the safety and overall viability of our Nation. The primary avenues for catastrophic damage to the Nation are through our electric power infrastructure and thence into our telecommunications, energy, and other infrastructures. These, in turn, can seriously impact other important aspects of our Nation's life, including the financial system; means of getting food, water, and medical care to the citizenry; trade; and production of goods and services. The recovery of any one of the key national infrastructures is dependent on the recovery of others. The longer the outage, the more problematic and uncertain the recovery will be. It is possible for the functional outages to become mutually reinforcing until at some point the degradation of infrastructure could have irreversible effects on the country's ability to support its population.⁵⁷

⁵⁷ Ibid, pp. 1-2.

The EMP Commission 2008 report, *Critical National Infrastructures*, uses even more assertive language that an EMP event will likely cause massive loss of life. "Should significant parts of the electrical 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," according to the 2008 report, "In fact, the Commission is deeply concerned that such impacts are likely in the event of an EMP attack..."⁵⁸

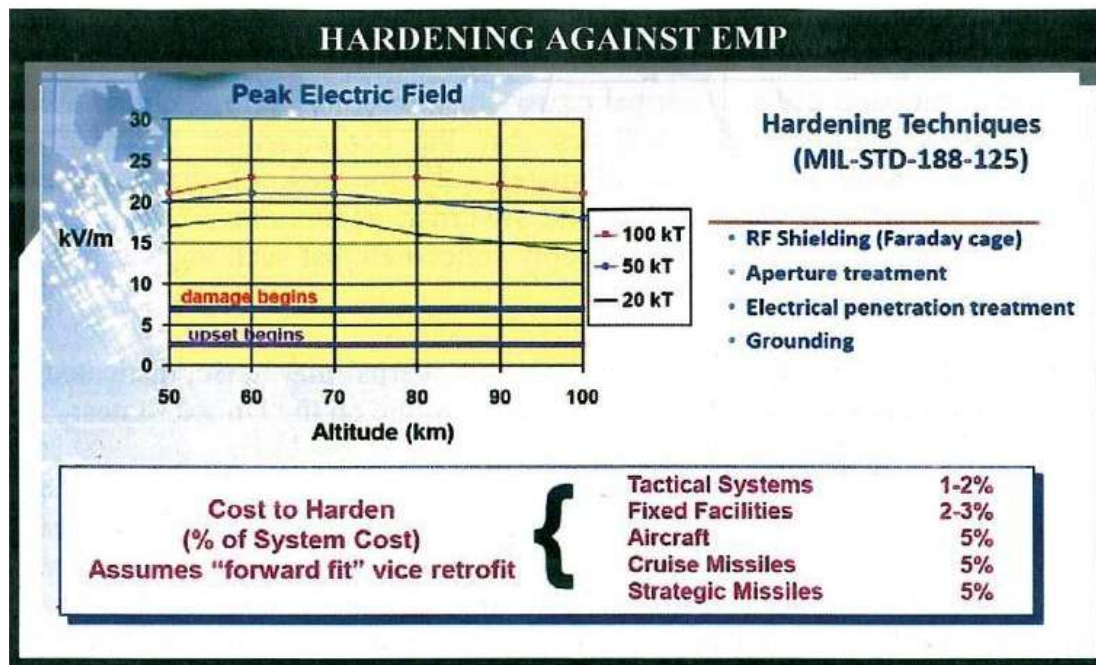
The EMP Commission *Executive Report* warns that unsophisticated actors, terrorists or rogue states, could inflict an EMP catastrophe on the United States:

*Another key difference from the past is that the U.S. has developed more than most other nations as a modern society heavily dependent on electronics, telecommunications, energy, information networks, and a rich set of financial and transportation systems that leverage modern technology. This asymmetry is a source of substantial economic, industrial, and societal advantages, but it creates vulnerabilities and critical interdependencies that are potentially disastrous to the United States. Therefore, terrorists or state actors that possess relatively unsophisticated missiles armed with nuclear weapons may well calculate that, instead of destroying a city or military base, they may obtain the greatest political-military utility from one or a few such weapons by using them--or threatening their use--in an EMP attack. The current vulnerability of U.S. critical infrastructures can both invite and reward attack if not corrected...*⁵⁹



⁵⁸ EMP Commission, op. cit. *Critical National Infrastructures*, p. vii

⁵⁹ Ibid, pp. 2-3.



Cost-effective technology and techniques for protecting against EMP have been known to the Department of Defense for decades. According to the EMP Commission, protecting the civilian critical infrastructures "is feasible and well within the Nation's means to accomplish." (Source: EMP Commission Briefing.)

The EMP Commission's *Executive Report* also warns that Mother Nature can pose an EMP threat to the United States by means of a geomagnetic storm:

Geomagnetic storms, a natural phenomenon driven by the solar wind, may, by a different physical mechanism, produce ground-induced currents (GIC) that can affect the electrical system in a manner similar to the E3 component of EMP. Disruptions caused by geomagnetic storms, such as the collapse of Quebec Hydro grid during the geomagnetic storm of 1989, have occurred many times in the past.⁶⁶

Unfortunately, although the EMP Commission briefed Congress on the threat from a great geomagnetic storm in 2004, premature termination of the Commission prevented its staff papers, including those on great geomagnetic storms, from being published. Four years later, in 2008, an independent study by the National Academy of Sciences reviewed and built upon the EMP Commission's work, to cast a public spotlight on the natural EMP threat from a great geomagnetic storm.

The National Academy of Sciences Report

In 2008, the National Academy of Sciences published its report on the natural EMP threat from a great geomagnetic storm, titled *Severe Space Weather Events-- Understanding Societal and Economic Impacts*. The NAS report focused on the natural EMP threat from a great geomagnetic storm, a new phenomenon to the scientific community discovered by the EMP Commission's previous work, and did not treat nuclear EMP.

⁶⁶ Ibid, pp. 17-18.

The NAS report was the collective product of a project, sponsored by the NAS Space Studies Board and the NAS Division on Engineering and Physical Sciences, which reviewed the EMP Commission's earlier work and performed their own independent assessment.⁶¹

Severe Space Weather Events concludes that geomagnetic storms can threaten the technologies, like power grids, communications, pipelines, and satellites, upon which modern societies depend:

*Modern society depends heavily on a variety of technologies that are susceptible to the extremes of space weather--severe disturbances of the upper atmosphere and of the near-Earth space environment that are driven by the magnetic activity of the Sun. Strong auroral currents can disrupt and damage modern electric power grids and may contribute to the corrosion of oil and gas pipelines. Magnetic storm-driven ionospheric density disturbances interfere with high frequency (HF) radio communications and navigation signals from Global Positioning System (GPS) satellites, while polar cap absorption (PCA) events can degrade--and, during severe events, completely black out--HF communications along transpolar aviation routes...Exposure of spacecraft to energetic particles...and radiation belt enhancements can cause temporary operational anomalies, damage critical electronics, degrade solar arrays, and blind optical systems...*⁶²

The NAS report, focusing on the natural EMP threat, raised the same questions as the EMP Commission; about whether the ever increasing vulnerability of technology has placed at risk our economy and society:

*Have recent technological developments made our critical technologies more or less vulnerable? How well do we understand the broader societal and economic impacts of extreme space weather events? Are our institutions prepared to cope with the effects of a "space weather Katrina," a rare but according to the historical record, not inconceivable eventuality?*⁶³

Severe Space Weather Events concludes, as did the EMP Commission, that a great geomagnetic storm could collapse critical infrastructures across the entire United States, causing the failure of and likely "disruption of transportation, communication, banking, and finance systems, and government services; the breakdown of the distribution of potable water..." A great geomagnetic storm could damage, not just the United States, but the international community:

⁶¹ National Academy of Sciences, *Severe Space Weather Events—Understanding Societal and Economic Impacts* (Washington, D.C.: National Academies Press, 2008).

⁶² *Ibid.*, p. I.

⁶³ *Ibid.*

Because of the interconnectedness of critical infrastructures in modern society, the impact of severe space weather events can go beyond disruption of existing technical systems and lead to short-term as well as long-term collateral socioeconomic disruption. Electric power is modern society's cornerstone technology, the technology on which virtually all other infrastructures and services depend. Although the probability of a wide-area electric power blackout resulting from an extreme space weather event is low, the consequences of such event could be very high, as effects would cascade through other dependent systems. Collateral effects of a longer-term outage would likely include, for example, disruption of the transportation, communication, banking, and finance systems, and government services; the breakdown of the distribution of potable water owing to pump failure; and the loss of perishable foods and medications because of lack of refrigeration. The resulting loss of services for a significant period of time in even one region of the country could affect the entire nation and have international impacts as well."

The National Academy of Sciences report warns that a great geomagnetic storm is a rare, but real, threat to the United States and the world:

Our knowledge and understanding of the vulnerabilities of modern technological infrastructure to severe space weather and the measures developed to mitigate those vulnerabilities are based largely on experience and knowledge gained during the past 20 or 30 years, during such episodes of severe space weather as the geomagnetic super storms of March 1989 and October-November 2003. As severe as some of these recent events have been, the historical record reveals that space weather of even greater severity has occurred in the past--e.g., the Carrington event of 1859 and the great geomagnetic storm of 1921--and suggests that such extreme events, though rare, are likely to occur again sometime in the future. While the socioeconomic impact of a future Carrington event are difficult to predict, it is not unreasonable to assume that an event of such magnitude would lead to much deeper and more widespread socioeconomic disruptions than occurred in 1859, when modern electricity-based technology was still in its infancy.

A more quantitative estimate of the potential impact of an unusually large space weather event has been obtained by examining the effects of a storm of the magnitude of the May 1921 super storm on today's electric power infrastructure. Despite the lessons learned since 1989 and their successful application during the October-November 2003 storms, the nation's electric power grids remain vulnerable to disruption and damage by severe space weather and have become even more so, in terms of both widespread blackouts and permanent equipment damage requiring long restoration times.⁶⁵

⁶⁵ Ibid, pp. 2-3.

The National Academy of Sciences *Severe Space Weather Events* warns that a great geomagnetic storm LIKE 1921 could TODAY inflict on the United States catastrophic damage, "an estimate of \$1 trillion to \$2 trillion during the first year alone...for the societal and economic costs...with recovery times of 4 to 10 years."⁶⁶ The 1859 Carrington Event is estimated to have been ten times more powerful than the 1921 geomagnetic storm.

The Strategic Posture Commission Report

In 2009, the Congressional Commission on the Strategic Posture of the United States issued its final report, *America's Strategic Posture*, which included the Commission's consensus view on the nuclear EMP threat. Congress established the blue ribbon Strategic Posture Commission in an effort to achieve a bipartisan consensus on a broad range of strategic issues, including the future role of nuclear weapons in U.S. national security policy, the condition of the U.S. nuclear weapons stockpile and industrial complex, and future challenges to the U.S. nuclear deterrent. Strategic Posture Commissioners and staff comprised America's strategic, foreign policy, and scientific elite, many of them historic figures. Dr. William J. Perry, Chairman of the Commission, served as Secretary of Defense under the Clinton administration. Dr. James R. Schlesinger, the Commission Vice Chairman, served as Secretary of Defense and Director of the Central Intelligence Agency. Other Commissioners included former astronaut and Senator John Glenn, former CIA Director James Woolsey, presidential advisor Dr. Fred Ikle, and Dr. Keith Payne, the architect of President George W. Bush's nuclear and arms control policy.⁶⁷

Significantly, although the Strategic Posture Commission was not specifically tasked by Congress to examine EMP--nonetheless, the Commission independently examined the nuclear EMP threat, and offered its consensus view. *America's Strategic Posture* notes that Strategic Posture Commissioners differed only over whether the nuclear EMP threat is imminent, a threat here now, or whether it is an emerging threat that will confront the nation in the near future. All Commissioners agreed terrorists and rogue states can, sooner or later, pose a nuclear EMP threat to the United States--with catastrophic consequences for the nation. *America's Strategic Posture*:

Lastly, the United States should take steps to reduce the vulnerability of the nation and the military to attacks with weapons designed to produce electromagnetic pulse (EMP) effects. We make this

⁶⁶ Ibid, p. 3.

⁶⁶ Ibid, p. 4.

⁶⁷ Strategic Posture Commission, *America's Strategic Posture: The Final Report of the Congressional Commission on the Strategic Posture of the United States* (Washington, D.C.: United States Institute of Peace Press, 2009), pp. 141-156.

recommendation although the Commission is divided over how imminent a threat this is. Some commissioners believe it to be a high priority threat, given foreign activities and terrorist intentions. Others see it as a serious potential threat, given the high level of vulnerability. Those vulnerabilities are of many kinds. U.S. power projection forces might be subjected to an EMP attack by an enemy calculating-- mistakenly--that such an attack would not involve risks of U.S. nuclear retaliation. The homeland might be attacked by terrorists or even state actors with an eye to crippling the U.S. economy and American society. From a technical perspective, it is possible that such attacks could have catastrophic consequences. For example, successful attacks could shut down the electrical system, disable the internet and computers and the economic activity on which they depend, incapacitate transportation systems (and thus the delivery of food and other goods), etc.⁶⁸

The consensus of the Strategic Posture Commission was the urgent implementation of the recommendations of the EMP Commission to protect U.S. critical infrastructures from a nuclear EMP attack:

Prior commissions have investigated U.S. vulnerabilities and found little activity underway to address them. Some limited defensive measures have been ordered by the Department of Defense to give some protection to important operational communications. But EMP vulnerabilities have not yet been addressed effectively by the Department of Homeland Security. The EMP Commission has recommended numerous measures that would mitigate the damage that might be wrought by an EMP attack. The Stimulus Bill of February 9, 2009, allocates \$11 billion to DOE for "smart grid activities, including to modernize the electric grid." Unless such improvements in the electric grid are focused in part on reducing EMP vulnerabilities, vulnerability might well increase.⁶⁹

So alarmed was the Strategic Posture Commission by the nuclear EMP threat that representatives from the Commission, Vice Chairman Schlesinger and Commissioner Iklé, met personally with the Deputy Secretary of the Department of Energy, Dr. Dan Poneman, to urge that DOE undertake steps to protect the national electric grid. Deputy Secretary Poneman shared the Commissioners concerns, himself having served as staff on the Strategic Posture Commission, and recently been appointed to the number two post at DOE.⁷⁰

However, Deputy Secretary Poneman, despite being one of the highest ranking officials in the nation empowered to oversee the national electric grid, and despite his strong personal commitment, nonetheless was limited in legal authorities and resources to tackle a problem that was much larger than DOE, and encompassed other agencies, the

⁶⁸ Ibid, pp. 90-91.

⁶⁹ Ibid, p. 91.

⁷⁰ The Principal Investigator of this study was personally present at the meetings.

Congress, and Industry. Poneman did what he could, launching initiatives at DOE to examine various technical options for protecting the grid from EMP, and encouraging the electric power industry to independently examine the EMP threat.

One result of Deputy Secretary Poneman's initiatives is the NERC-DOE report of 2010.

The NERC-DOE Report

In June 2010, the North American Electric Reliability Corporation (NERC) and the U.S. Department of Energy released their joint report *High-Impact, Low-Frequency Event Risk to the North American Bulk Power System*. The NERC-DOE report was the result of a joint project by the electric power industry, represented by NERC--a private sector corporation for the collective electric utilities of North America--and government, represented in the project by DOE. The report also included the Department of Defense, the Department of Homeland Security and other agencies. 110 experts from industry and government participated in the project, the NERC-DOE *High-Impact* report representing their collective views.⁷¹

The North American Electric Reliability Corporation is decidedly pro-industry and anti-government regulation in its orientation. Going into the NERC-DOE project, NERC was known as an organization to be among the most skeptical and resistant toward further burdening the electric power industry with additional government imposed requirements. Indeed, opposing additional government regulations is NERC's business.

Yet, much to NERC's credit, after rigorously reviewing the data, the NERC-DOE *High-Impact* report arrived at the same consensus view about the EMP threat, and the necessity to act, as did the EMP Commission, the National Academy of Sciences, and the Strategic Posture Commission.

Of the natural EMP threat from a great geomagnetic storm, the NERC-DOE *High-Impact* report warns that great geomagnetic storms are, in fact, a real threat to the entire planet: "Large geomagnetic storms can have a global reach and produce impacts to other developed power grids around the world."⁷²

High-Impact acknowledges that current safeguards to protect electric grids against geomagnetic storms may be inadequate, and more work is needed to provide for their safety:

Geomagnetic disturbances, the earthly effects of solar weather, are not a new threat to the electric sector. Recent analysis by Metatech and Storm Analysis Consultants suggests, however, that the potential extremes

⁷¹ North American Electric Reliability Corporation (NERC) and the Department of Energy (DOE), *High-Impact, Low-Frequency Event Risk to the North American Bulk Power System* (June 2010), p. 2.

⁷² *Ibid*, p. 64.

of the geomagnetic threat environment may be much greater than previously anticipated. Geomagnetically-induced currents on system infrastructure have the potential to result in widespread tripping of key transmission lines and irreversible physical damage to large transformers., The 1989 event that caused a blackout of the Hydro Quebec system provided important lessons to the sector. Since that time, the sector has adopted operational procedures to reduce the vulnerability to geomagnetic storms and has installed certain protections in areas most prone to impact as recommended by Oak Ridge National Labs in their report on the March 1989 event. More work is needed, however, to consider the potential impacts larger storms may have and develop viable, cost-effective mitigations, potentially at lower geographic latitudes than previously thought necessary.⁷³

The NERC-DOE report acknowledges the threat from nuclear EMP and from non-nuclear EMP weapons:

The high-altitude detonation of a large nuclear device or other electromagnetic weapon could have devastating effects on the electric sector, interrupting system operation and potentially damaging many devices simultaneously. A coordinated attack involving intentional electromagnetic interference (IEMI) could result in more localized and targeted impacts that may also cause significant impacts to the sector.⁷⁴

Indeed, the *High-Impact* report warns that a nuclear EMP attack against the United States may be more likely now than in the past:

While it is extremely challenging to place a probability on the occurrence of such a deliberate attack on the North American continent, military thought places the continent at greater risk for such an attack today than in the past. As the military landscape has changed from nation-state threats to a greater concern over terrorist and rogue-state threats, the risk for the use of weapons of mass destruction (such as a EMP weapon) has increased. Adversaries are more likely to resort to asymmetric means, using unconventional approaches that avoid or undermine North America's strengths and instead exploit vulnerabilities. This means that the future target of HEMP may well be the civil infrastructure of the United States as opposed to military systems, which have considered the HEMP threat for many years.⁷⁵

The NERC-DOE report warns that a natural, nuclear, or non-nuclear EMP event could so damage the national electric grid that recovery could take years, and recommends prioritizing and undertaking steps to protect the system:

⁷³ Ibid, p. 11.

⁷⁴ Ibid.

⁷⁵ Ibid, p. 77.

The physical damage of certain system components (e.g., extra-high-voltage transformers) on a large scale, as could be effected by any of these threats, could result in prolonged outages as procurement cycles for these components range from months to years. Many of these components are manufactured overseas, with little manufacturing capability remaining in North America. The impacts of these events on the power system are not yet fully understood across the sector and warrant further collaborative work to identify the prioritized "top ten" mitigation steps that are both cost-effective and sufficient to protect the power system from the widespread catastrophic damage that could result from any of these events.⁷⁶

The FERC Interagency Report

In September 2010, the Federal Energy Regulatory Commission--an agency of the U.S. Government that oversees the electric power industry--released a major interagency report, intended to be the definitive last word on the EMP threat. The FERC team included participation by all relevant U.S. Government departments and agencies, including the Department of Homeland Security, the Department of Energy, Oak Ridge National Laboratory, and the White House Office of Science and Technology.

The FERC Interagency Report is really a series of in-depth reports, including an Executive Summary titled *Electromagnetic Pulse: Effects on the U.S. Power Grid*. Other reports in the study treat natural EMP, nuclear EMP, non-nuclear EMP, and measures for EMP protection:

- Geomagnetic Storms and Their Impacts on the U.S. Power Grid*
- The Early-Time (E1) High-Altitude Electromagnetic Pulse (HEMP) and Its Impact on the U.S. Power Grid*
- The Late-Time (E3) High-Altitude Electromagnetic Pulse (HEMP) and Its Impact on the U.S. Power Grid*
- Low-Frequency Protection Concepts for the Electric Power Grid*
- Intentional Electromagnetic Interference (IEMI) and Its Impact on the U.S. Power Grid*
- High-Frequency Protection Concepts for the Electric Power Grid*⁷⁷

⁷⁶ Ibid, p. 12.

⁷⁷ Federal Energy Regulatory Commission (FERC) Interagency Report, *Electromagnetic Pulse: Effects on the U.S. Power Grid*, Executive Summary (2010); FERC Interagency Report by John Kappenman, *Geomagnetic Storms and Their Impacts on the U.S. Power Grid* (Meta-R-319) Metatech Corporation (January 2010); FERC Interagency Report by Edward Savage, James Gilbert and William Radasky, *The Early-Time (E1) High-Altitude Electromagnetic Pulse (HEMP) and Its Impact on the U.S. Power Grid* (Meta-R-320) Metatech Corporation (January 2010); FERC Interagency Report by James Gilbert, John Kappenman, William Radasky, and Edward Savage, *The Late-Time (E3) High-Altitude Electromagnetic Pulse (HEMP) and Its Impact on the U.S. Power Grid* (Meta-R-321) Metatech Corporation (January 2010); FERC Interagency Report by John Kappenman, *Low-Frequency Protection Concepts for the Electric*

The FERC Interagency Report concurs with all previous reports--the EMP Commission, the National Academy of Sciences, the Strategic Posture Commission, and the NERC-DOE Report. According to the report Executive Summary, natural EMP, nuclear EMP, and non-nuclear EMP are potentially catastrophic threats that require urgent attention from Government and Industry. Like the EMP Commission, the FERC Interagency Report emphasizes that solutions to the EMP threat are readily at hand, and affordable: "...the average yearly cost of installing equipment to mitigate an EMP event is estimated at less than 20 cents per year for the average residential customer." *Electromagnetic Pulse: Effects on the U.S. Power Grid*, the report Executive Summary, offers this assessment:

*The nation's power grid is vulnerable to the effects of an electromagnetic pulse (EMP), a sudden burst of electromagnetic radiation resulting from a natural or man-made event. EMP events occur with little or no warning and can have catastrophic effects, including causing outages to major portions of the U.S. power grid possibly lasting for months or longer. Naturally occurring EMPs are produced as part of the normal cyclical activity of the sun while man-made EMPs, including Intentional Electromagnetic Interference (IEMI) devices and High Altitude Electromagnetic Pulse (HEMP), are produced by devices designed specifically to disrupt or destroy electronic equipment or by the detonation of a nuclear device high above the earth's atmosphere. EMP threats have the potential to cause wide scale long-term losses with economic costs to the United States that vary with the magnitude of the event. The cost of damage from the most extreme solar event has been estimated at \$1 to \$2 trillion with a recovery time of four to ten years, while the average yearly cost of installing equipment to mitigate an EMP event is estimated at less than 20 cents per year for the average residential customer.*⁷⁸

The consensus recommendation of the FERC Interagency Report is that, "The U.S. power industry must implement mitigation technologies to prevent catastrophic impacts to the grid resulting from EMP threats."⁷⁹

Power Grid: Geomagnetically Induced Current (GIC) and E3 HEMP (Meta-R-322) Metatech Corporation (January 2010); FERC Interagency Report by William Radasky and Edward Savage, *Intentional Electromagnetic Interference (IEMI) and Its Impact on the U.S. Power Grid* (Meta-R-323) Metatech Corporation (January 2010); FERC Interagency Report by William Radasky and Edward Savage, *High-Frequency Protection Concepts for the Electric Power Grid* (Meta-R-324) Metatech Corporation (January 2010).

⁷⁸ Ibid Executive Summary, p. i.

⁷⁹ Ibid, p. iv.