Global Single Point Failure[1]

The security flaw that could lead to continent-scale catastrophe

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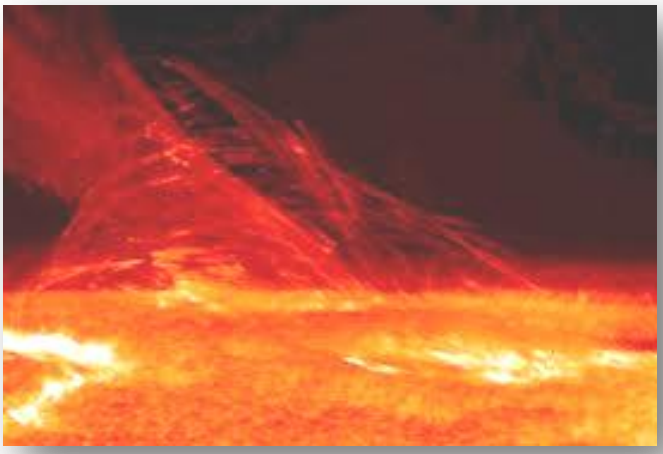
In 1962, deep in a cold war with the Soviet Union, the United States conducted "Starfish Prime," *a nuclear weapon test over a remote region of the Pacific Ocean. The test was successful, with one unexpected result: Fifteen hundred kilometers away streetlights burned out, TV sets and radios failed and power lines fused in parts of Hawaii. Three similar Soviet tests that same year over Kazakhstan caused more serious infrastructure problems, long before the delicate and ubiquitous microchips that power today's world.*

The unexpected events that took place in 1962 heralded what may be the most dangerous threat ever conceived against modern societies. A nuclear warhead set off above the atmosphere causes a High Altitude Electromagnetic Pulse, or (H)EMP. Unlike a ground burst, an HEMP blast could cause catastrophic damage over broad areas of a continent, a capability now in the hands of any rogue nation or terror organization that can acquire a single nuclear-tipped missile.



Solar flare image, NASA's JAXA Hinode spacecraft, 2007

At the same time, recent research by the National Academy of Sciences has concluded that the world's electric grids are threatened by a natural event that could have similar, devastating consequences. Based on this recent research, unusually severe solar flares have occurred about once per century, at a level that could burn out electric infrastructures world-wide.

These two infrastructure threats have been receiving increasing attention from the U.S. and allied governments.

In regard to EMP, with some of the world's most unstable regional powers acquiring or already in possession of nuclear weapons, the United States Congress established the EMP Commission,[2] tasked with evaluating this growing threat. The Commission, based on testimony from throughout the federal government,[3] warned that America's current vulnerability invites attack. They concluded, remarkably:

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[1] A *Single Point Failure* is part of a system whose failure would cause complete system failure.

By building unprotected, vulnerable computers and microprocessors into all the developed world's vital infrastructures, we have inadvertently created a *global single point failure*, putting a vast destructive potential into the hands of any group that can acquire a nuclear missile.

[2] See: *The Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack (April, 2008 – 181 pp).*

"EMP is capable of causing catastrophe for the nation," as *"one of a small number of threats that has the potential to hold our society seriously at risk, and might result in defeat of our military forces."*

In regard to both EMP and severe solar flares, recent reports by the Department of Energy, the Department of Homeland Security and the Federal Energy Regulatory Commission, as well as Congressional legislative action, all point to a need for urgent action, and growing interest in the international community has also brought this need to the attention of senior government leaders world wide. The EIS Council is dedicated to helping host this educational process internationally, working with concerned governments and organizations to frame a rapid response to this catastrophic threat.

What is EMP?

EMP is not new. The threat was a central element of the superpowers' nuclear confrontation throughout the cold war.

Since the first atmospheric nuclear tests fifty years ago, it has been known that a single nuclear weapon exploded above the Earth's atmosphere produces this high altitude electromagnetic pulse, radiating down to the Earth in a massive electrical surge of over 10,000 volts per meter. An EMP weapon's range depends on its altitude: it hits everywhere on a continent not blocked by the earth's curvature, and strikes about ten times as fast as lighting. It has the potential to damage or destroy computers, electronics and critical control systems that could, in turn, destroy much or most of a nation's electric grid, with damage to critical components that could mean a blackout lasting months or even years.

An HEMP strike destroys critical infrastructures with two different effects: An HEMP pulse can hit both critical hardware components, and the systems that control and use them. These two effects, combined, have a devastating impact.

Most vulnerable are the delicate SCADA[4] control systems and protective relays that run almost all modern installations – from national power stations to city water supply networks, oil refineries and pipelines, telephone networks, air traffic control systems and many others. Failure of these control systems and relays cascades quickly to catastrophic failure of much or all of the national electric grid, and of most other critical infrastructures.

While this effect alone is sufficient to destroy key installations, in many cases an HEMP pulse can directly destroy the critical hardware in these installations: computers, electronics, high voltage transformers and generators are all vulnerable.

History revisited: Throughout the cold war the U.S. and Russia had extensive EMP laboratories and testing programs, viewing HEMP as the first step in a nuclear exchange. It was never used because of the threat of massive retaliation.

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[3] The *Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack* requested and received information from a number of Federal agencies and National Laboratories, including the North American Electric Reliability Corporation, the President's National Security Telecommunications Advisory Committee, the Department of Homeland Security, the Federal Reserve Board, Los Alamos National Laboratory, Sandia National Laboratory, Argonne National Laboratory, Idaho National Laboratory, Naval Surface Warfare Center-Dahlgren and many other organizations.

[4] SCADA is an acronym for "System for Control and Data Acquisition"

"What is different now," the EMP Commission reports, *"is that some potential sources of EMP threats are difficult to deter – they can be terrorist groups that … have only one or a few weapons, and are motivated to attack … without regard for their own safety. Rogue states such as North Korea and Iran may also be … unpredictable and difficult to deter."*

In addition to the nuclear HEMP threat – by far the most devastating weapon of its kind – a wide range of plans has been publicly discussed for simpler, non-nuclear electromagnetic weapons or IEMI (Intentional Electromagnetic Interference) devices , with designs in varying degrees of detail widely disseminated. For example, a van filled with such a device is estimated to be adequate to destroy much of the electronic infrastructure of a major metropolitan area.[5]

Severe geomagnetic storms: the risk of a solar-induced electric grid catastrophe

NASA and the National Academy of Sciences predict a naturally-occurring solar event with consequences comparable to a nuclear EMP strike about once per century. The last such event occurred in 1859.

In February 2009, the National Academy of Sciences completed a NASA-funded study looking at the risk of an HEMP-like crisis caused by a severe geomagnetic storm. The study concluded: Solar activity that could cause severe, potentially nation-wide damage to the electric grid is expected roughly once in a hundred years. The last such event took place in 1859, with eight days of severe solar weather bringing auroras all the way to the equator, shutting down telegraph networks all over the world.

The National Academy of Sciences concluded: A severe geomagnetic storm could destroy the several hundred key U.S. transformers within 90 seconds, cutting off most of America's power.

Solar activity tends to peak on an approximate eleven year cycle. While it is impossible to know in advance when a 100-year severe storm will occur, the next peak in the eleven year cycle is expected in 2013.

What it means

The consequence of a severe solar flare or a single nuclear explosion high over a country like the United States could mean the end of the nation as we know it.

An EMP strike or a severe geomagnetic storm could destroy computers and computer networks throughout the country, and could disrupt the economy by severely damaging its banking and financial databases. It could burn out the telephone networks, cell phones, the internet, email, radio and television. If enough power station relays and control systems are destroyed it would shut down one or more of the nation's three regional electric grids – and the resulting destruction of transformers and generators in many of the nation's roughly 600 high-voltage power stations could mean a long term blackout over vast regions that could last for years. It could shut down the oil pipelines as well as the retail gas station networks, draining the fuel from the nation's transportation system and quickly bringing autos, trucks and other vehicles to a halt. There would be severe risks for critical installations, from nuclear power stations to dams. Production and distribution of food, pharmaceuticals and medicine would be drastically affected. It could disrupt the government, stop water and waste management systems, drive oil refineries out of control and cripple the nation's military.

It could shatter the foundation of modern society.

The weak, the very old and very young would be at greatest risk. Anyone traveling by airplane, patients requiring specialized health care, those with pace makers or other life-critical electrical devices would face an immediate crisis. The EMP Commission warns of the potential for "unprecedented cascading failures of our

[5] September 2001 Popular Mechanics Cover Story. *E-Bombs And Terrorists: In the blink of an eye, electromagnetic bombs could throw civilization back 200 years. And terrorists can build them for $400.*

major infrastructures," which could have "irreversible effects on the country's ability to support its population."[6] Severe damage to the social, agricultural, economic, health and security networks would mean food shortages, starvation, disease and civil unrest. Although the impact could be reduced by inventive use of remaining impaired infrastructures, tens of millions could die within a year of such an attack. Japan and South Korea, Israel and other Middle East nations, India, Western Europe and the UK are equally vulnerable.

The EMP Commission found that numerous foreign governments are addressing the threat. Russia, for example, has invested in both developing advanced EMP threats and in protecting its civilian and military infrastructures. Thus in 1999, when tensions rose over Yugoslavia, Russia's Duma International Affairs Committee warned a U.S. House Armed Services Committee delegation:

> *"Hypothetically,"* the Russian committee chairman said, *"if Russia really wanted to hurt the United States ... Russia could ... detonate a single nuclear warhead at high-altitude over the United States. The resulting electromagnetic pulse would massively disrupt U.S. communications and computer systems, shutting down everything."* [7]

The EMP Commission found that knowledge of this threat is particularly widespread in the world's most dangerous nations, including Iran and North Korea.

North Korea

In 2004 the EMP commission met with very senior Russian military officers, who warned that Russian scientists had been recruited by Pyongyang to work on the North Korean nuclear weapons program. They warned that, at that time, the knowledge to develop "Super-EMP" weapons had already been transferred to North Korea, estimating that North Korea could probably develop such advanced EMP weapons within a few years, (i.e., by around 2006).[8]

Iran

According to the EMP Commission, Iran has performed a missile test in what appears to be a simulated, sea-launched nuclear EMP strike. In addition, according to Senate testimony,[9] an Iranian military journal publicly discussed using EMP against the West.

> *"Once you confuse the enemy communication network,"* the Iranian journal said, *" ... you will, in effect, disrupt all the affairs of that country. If the world's industrial countries fail to devise effective ways to defend themselves against dangerous electronic assaults then they will disintegrate within a few years."*[10]

It is also important to note that, while a high altitude HEMP attack could encompass large regions or potentially an entire continent, a more limited attack is possible from altitudes as low as 30 km, reachable by missiles in the known inventories of many terrorist groups. If such a group can acquire a small nuclear weapon, they could use even a short range missile to deliver a crushing regional attack.

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[6] *The Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack*, Vol.1, Executive Report, 2004

[7] HASC Transcript On Vienna Conference, 2 May 1999

[8] Statement of Dr. Peter Vincent Pry, EMP Commission Staff, before the United States Senate Subcommittee on Terrorism, Technology and Homeland Security, March 8, 2005: *Foreign Views of Electromagnetic Pulse (EMP) Attack*

[9] ibid

[10] *"Electronics to determine the fate of future wars,"* Tehran, Nashriyeh-e Siasi Nezami, December 1998 -January 1999

Global single point failure

"We have created our own Achilles' heel of vulnerability."
– Senator Jon Kyl, speaking about the EMP threat to America.

For decades the world, led by the most developed nations of the West, has been systematically transforming all essential economic, food, fuel, water, transportation, defense, medical care and communication systems into efficient electronically-based networks that are exposed and vulnerable to this threat.

The western world has unwittingly converted every infrastructure that supports our lives and our economies to depend on microchips that are all vulnerable to a severe solar-induced geomagnetic storm or a single high altitude nuclear burst above a continent. We have inadvertently engineered a single point failure into the foundation of the modern world, and the very fabric of our lives.

This extreme vulnerability gives any rogue nation or terrorist group that can acquire a handful of nuclear missiles the capability to create unprecedented catastrophe for modern civilization.

What can be done

"Correction is feasible: We can prevent an EMP catastrophe." — The U.S. EMP Commission

The EMP Commission's report recommends three critical areas of effort to reverse this vulnerability:

- Deterrence – Prevent rogue states and their terrorist allies from acquiring the weapons
- Defense – Defeating an attempted HEMP attack by intercepting the threat
- Protection and Recovery – Protecting civilian and military infrastructures and emergency response capabilities, maintaining extensive spare parts for emergency repairs, and training response teams

  The commission placed its primary emphasis on protection and recovery: Their conclusion – infrastructure protection is affordable, feasible and timely. Estimated electric grid protection costs for the United States are estimated to be less than $1B. Since much of this cost would in any case be incurred for normal periodic upgrade and modernization, the net costs are even lower. The most critical first steps can be implemented within the first year or two, quickly taking the most devastating scenarios off the table.

Critical first steps

At the national level, there are a handful of critical high priority actions that can begin quickly, correcting the most severe vulnerabilities.

1. **Protect the integrity of the national government and other critical national institutions:** EMP protection for essential government facilities and operations.
2. **Protect key power stations, all nuclear power facilities and critical installations:** Use an EMP-vulnerability electric grid model to develop an optimized plan for a combination of EMI shielding, advanced grounding, "surge protectors" and selected low-sensitivity network components for critical electric grid control systems, transformers and generators. Protection for power stations should be prioritized in stages, to assure that – even in the first stage – power will still be available for critical priorities.
3. **Emergency food supply and distribution**: Fully implement plans for a national emergency food supply and distribution. Install protection hardware to assure the integrity of the water system, and implement planning for priority routing of available grid power to these systems.

4. **Adapted emergency planning:** Implement a "phase one" long-term grid failure emergency plan to prepare and train emergency personnel to address the most critical community safety needs
5. **Public awareness and preparedness:** Individuals and institutions should be given appropriate information on the government's grid-failure protection and recovery plans, and encouraged to develop their own emergency planning.

The role of the Electric Infrastructure Security Council

The most important effective path to quickly developing a robust response to severe power grid threats is through international cooperation.

Recognizing and acting on the need to address this threat requires political agility and international cooperation. Historically, nations have been slow to take proactive action to perceived fundamental threats, often waiting until after the threat hits, responding to limit the threat while trying to recover.

With severe solar flares or EMP we do not have that option. Rogue states and trans-national terror groups ideologically dedicated to widespread destruction are working successfully to improve their access to nuclear weapons and missiles. The recent NAS report has clarified that, barring some change in the physics of the sun, a severe geomagnetic storm will definitely happen. Failure to take *proactive* action against this threat could mean a devastating attack, and irreversible, widespread destruction.

International cooperation can help substantially, by pooling resources and reducing the financial and technical barriers to taking effective action. In this regard, one of the most successful recent political trends in the world's democracies has been the development of highly effective non-government organizations. NGOs have rapidly become engines for growth and development of robust, healthy new policies in most Western democracies. Many such organizations have demonstrated an ability to supplement the role of government, often participating in government – NGO partnerships, taking roles requiring nimble and creative action that are difficult for large government institutions without such partners. This has given rise to a new reality, with government often working with NGOs to help them take on such roles.

This kind of partnership can be an important tool in responding to this threat as well, and the EIS Council and its partners are working to help host an international framework for proactive action, to help assure a healthy, thriving future for our nations and the world.

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