The Institute for Foreign Policy Analysis

National Security Update

The Trump Administration's Executive Order on Electromagnetic Pulse

This *IFPA National Security Update* examines President Trump's Executive Order (EO) on Electromagnetic Pulse (EMP), the threat posed by EMPs, how the EO addresses that threat, and what other steps should be taken to counter both man-made and naturally-occurring EMP events.

Key Conclusions and Findings

- President Trump's March 2019 EMP Executive Order is the first comprehensive government-wide policy to protect the nation against naturally-occurring (solar storms) or man-made EMP (via detonation of a nuclear device).
    - Either type of EMP event could render the U.S. infrastructure inoperable, cripple society, and result in millions of casualties.
- The EO mandates several immediate actions and studies to protect critical infrastructure, key systems, and networks most at risk from EMP and is designed to increase preparedness against EMP events through enhanced public and private coordination and planning. The EO places the White House in charge of this effort.
- The EO directs the Department of Defense (DOD) to deter and defend against man-made EMP attacks. For the first time, deterrence and defense against man-made EMP is stated explicitly to be a defined mission of the U.S. military.
- The most effective approach to combat man-made EMPs is by boost-phase intercept (BPI) missile defense capabilities. Consequently, the United States should:
    - Develop/field a near-term BPI capability based on the F-35 aircraft;
    - Develop/field a space-based-intercept layer drawing on the *Brilliant Pebbles* space-intercept concept, an operational capability proven in 1989-90 timeframe; and,
    - Fast-track testing of the U.S. Navy's Standard Missile-3 IIA interceptor missile to determine if it can defend against ICBMs. If proved capable against ICBMs, SM-3 IIAs deployed in *Aegis* Ashore batteries along the U.S. Gulf Coast could counter the southern-trajectory and terrorist-ship-launched EMP threat.
- The EO also directs DOD and other federal agencies to augment coordination and data sharing on EMP within the government and with the private sector.

- This is important because oftentimes EMP studies, particularly those undertaken in the private sector and by research organizations, do not have or intentionally do not use, accurate information/data, which skews study findings resulting in faulty and inaccurate conclusions about what is needed to protect critical infrastructures from EMP events.
- More robust data sharing will help minimize mistakes and help reduce bias in such studies.

- To sustain the momentum of President Trump's EO, uninterrupted support and management from the White House is needed.
  - The White House must hold the feet of stakeholders in government departments/agencies and in the private sector to the fire in order to ensure implementation of the initiative and to forestall it becoming bogged down by bureaucratic inertia, slow-rolling by entrenched opposition, and lobbying.
  - Supporters in Congress in the committees and subcommittees who have responsibility for the U.S. critical infrastructure and EMP-related issues must also provide oversight and pass legislation where necessary to advance the goals of the EO.

Introduction

The United States confronts a major threat from an electromagnetic pulse event. An EMP event could materialize in two forms, nuclear or non-nuclear, and it can either be man-made or originate by natural occurrences such as solar storms.

In a worst-case scenario, an EMP attack with a nuclear weapon could render the U.S. infrastructure inoperable, cripple our society, and lead to deaths numbering in the millions. A natural EMP incident such as an intense solar storm could also result in catastrophic human and physical damage.

The EMP threat can be countered in several ways. As described in greater detail in upcoming sections, a man-made EMP event such as a nuclear EMP attack can be thwarted by active defenses. These include ballistic missile defenses together with left-of-launch interdictions (i.e., destruction of the ballistic missile prior to launch with kinetic systems) and cyber operations (to cause enemy ballistic missiles to explode, veer off course, or otherwise malfunction).[i]

A naturally occurring EMP event produced by a solar storm can be addressed by what is referred to as passive measures, i.e., hardening our life-sustaining critical infrastructures, especially the electric power grid, and taking other measures to ensure the resilience of these infrastructures. Protecting/hardening critical U.S. infrastructures, networks, and nodes also provides protection against man-made EMP threats.

To date however, the EMP threat, its implications, and the development of strategies/methods to counter it have not been sufficiently addressed by U.S. government decision makers: this

lack of attention and planning is bewildering given the potential ruinous ramifications a man-made or natural EMP event holds for the United States.

President's Executive Order to Counter EMPs

Fortunately, on March 26, 2019 the Trump Administration took a major step to deal with the EMP threat when the President signed an Executive Order entitled "Coordinating National Resilience to Electromagnetic Pulses." It represents the first ever comprehensive government-wide policy to protect the United States against EMP. The EO calls for a "whole-of-government approach" to protect the key systems, networks, and assets most at risk from EMPs. It wisely puts the White House in charge of managing the preparedness of the United States against naturally-occurring and man-made EMP events.[ii] (more below).

It will enhance our readiness against EMP events through increased public and private coordination and planning. The Executive Order is also an important step in raising the visibility and awareness of our growing vulnerability to EMP both within the U.S. government and at a broader public level.

The President's EO came about in large part because of the seminal work of the Commission to Assess the Threat to the United States from Electromagnetic Pulse Attack (the EMP Commission)[iii] and organizations such as the Independent Working Group (IWG) on Missile Defense.[iv]

The Congressionally mandated EMP Commission generated detailed studies and the IWG published numerous publications which together highlighted the deleterious impacts of both man-made and naturally-occurring EMP as well as viable approaches to counter them.[v] The EO implements the core recommendations set forth by the EMP Commission and the IWG, stating that "The Federal Government must foster sustainable, efficient, and cost-effective approaches to improving the Nation's resilience to the effects of EMPs."[vi]

An immediate positive result of the Executive Order has been the initiation of several studies to be conducted by various government departments and agencies including the Departments of Homeland Security, Defense, Energy, Interior, and Commerce, and the Office of the Director of National Intelligence. Many of these studies require near-term reporting deadlines. For example:

- "Within 90 days of the date of this order, the Secretary of Homeland Security … shall identify and list the national critical infrastructures . . . that, if disrupted, could reasonably result in catastrophic national or regional effects."

- "Within 180 days of the date of this order, the Secretary of Homeland Security … shall review and update Federal response plans, programs, and procedures to account for the effects of EMPs."

- "Within 1 year of the date of this order … the Secretary of Homeland Security … shall submit to the President … a report that analyzes the technology options available to improve the resilience of critical infrastructure to the effects of EMPs."

- "Within 1 year of the date of this order, the Secretary of Homeland Security … shall identify regulatory and non-regulatory mechanisms, including cost recovery mechanisms, that can enhance private-sector engagement to address the effects of EMPs."

- "Within 1 year of the date of this order … the Secretary of Energy … shall review existing standards for EMPs and develop or update … quantitative benchmarks that sufficiently describe the physical characteristics of EMPs, including waveform and intensity, in a form that is useful to and can be shared with owners and operators of critical infrastructure."

- "Within 1 year of the date of this order, and every 2 years thereafter, the Secretary of Homeland Security, in coordination with the Secretaries of Defense and Energy … and in consultation with … private-sector partners as appropriate, shall submit to the President a report that analyzes the technology options available to improve the resilience of critical infrastructure to the effects of EMPs. The Secretaries of Defense, Energy, and Homeland Security shall also identify gaps in available technologies and opportunities for future technological developments to inform R&D activities."[vii]

As noted, the results of the studies and directives mandated in the EO will be reported directly to the White House which the EO prudently puts in charge of managing the preparedness of the United States against man-made and naturally-occurring EMP events (this was another key recommendation of the EMP Commission and the IWG). Both types of EMP events are described in greater detail below.

It's About Time! The Executive Order Directs DOD to Deter and Defend Against EMP Attacks

A critical element of the President's EO that has received little-to-no attention but should have major implications for combatting the man-made EMP threat is the fact that the Secretary of Defense is directed to:

- "defend the Nation from adversarial EMPs originating outside of the United States through defense and deterrence, consistent with the mission and national security policy of the Department of Defense."

This means that for the first time deterring and defending against man-made EMP attacks should become an explicit, defined mission of the Department of Defense. This is a welcome development – albeit one that is long overdue. It is instructive to note that in the Administration's January 2019 Missile Defense Review (MDR)[viii] which set forth the range of nuclear and missile threats facing the United States and outlined U.S. missile defense strategies and programs to counter them, the threat posed by electromagnetic pulse was *not* mentioned a single time in the document.[ix]

The President's EO rectifies this omission, correcting the absence of focus on the EMP threat in DOD planning and programs. DOD must now improve the capabilities, i.e., missile defense assets, left-of-launch and cyber capacities, intelligence capabilities, and develop the attendant concept of operations specifically designed to counter burgeoning "adversarial EMPs."

Man-Made EMP and Its Potential Impacts

The most lethal form of man-made EMP results from the detonation of a nuclear weapon. It occurs when a nuclear weapon explodes high in, or above, the atmosphere at an altitude between 25 to 249 miles. The detonation releases photons in the form of gamma radiation and x-rays which disperse rapidly in every direction from the blast.

The potential impact of an EMP is determined by the altitude of the nuclear detonation and the amount of gamma radiation generated. These energetic particles produce massive current and voltage surges, disabling, damaging, or destroying unhardened electronic equipment, electric power systems, and other critical infrastructures on the ground and in space within the vicinity of the nuclear-blast radius. Most of the U.S. civilian infrastructure is unhardened and thus highly susceptible to EMP.

The effects of an EMP attack would be catastrophic with the subsequent radiation released extending for many miles. For example, a nuclear weapon detonated at a height of approximately 62 miles would expose objects located within an area 725 miles in diameter to EMP, causing massive voltage spikes that could destroy vital U.S. electronic infrastructure including the electric grid, energy, telecommunications networks, transportation systems, banking, the movement of inventories, and food processing and distribution capabilities. Greater burst heights would expose even larger areas to the deleterious impacts of EMP.

The consequences of man-made EMP were discovered in the early 1960s following U.S. atmospheric nuclear-weapons tests in the Central Pacific. On July 9, 1962 during the Starfish Prime test, a 1.4 megaton nuclear weapon was detonated 249 miles above Johnston Island in the Pacific Ocean. The effects were felt 870 miles away in Hawaii: street lights, alarms, circuit breakers, and communications equipment showed signs of distortions and considerable damage. In addition, the EMP generated by the Starfish Prime detonation damaged at least six satellites, all of which eventually failed due to the blast. Other satellite failures following the test were linked to the effects of the detonation.[x]

Today, the destruction resulting from an EMP detonation would be substantially greater than at the time of the Starfish Prime test given the ubiquity of fragile electronic devices and systems coupled with far greater numbers of satellites extant today and our greater reliance on them to run critical infrastructures and defense systems. U.S. satellites, both civilian and military – but especially the former which are largely unhardened – are particularly vulnerable to EMP effects as was demonstrated following the Starfish Prime test. Because the United States is the most dependent nation on space capabilities/assets relying on them for virtually all of its military operations, it is also the most vulnerable to an EMP attack.

In addition, the national security and homeland security communities depend on commercial satellites for critical activities including direct and backup communications, emergency response services, and continuity of operations during emergencies.[xi] U.S. space systems in low-Earth orbits are particularly susceptible to EMP attacks. Moreover, EMP could have devastating consequences for the control systems and ground infrastructure of space systems. The destruction or disabling of such satellites would have catastrophic implications for homeland security and for the U.S. military as well as for the overall economy and society.

Depending on the specific characteristics of an EMP attack, unprecedented cascading failures of our major infrastructures could result. Disabling even one of the elements of our critical infrastructure, such as electricity or telecommunications, would have severe consequences for others – effects from which an advanced, technologically dependent society such as the United States might not easily recover. In that event, a regional or national recovery would be long and difficult and seriously degrade the safety and overall viability of the United States.

The primary paths for catastrophic damage to the United States are through our electric power infrastructure and subsequently into our telecommunications, energy, and other infrastructures. These, in turn, can seriously impact other vital life-sustaining elements including: the means of getting food, water, and medical care to the citizenry; the financial system; 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.

Who Could Carry Out a Nuclear EMP Strike?

As noted earlier, an EMP attack is one of the most serious, but disturbingly least acknowledged threats currently confronting the United States and its allies. Although EMP threats have existed for several decades, they are far more prevalent today because technology has evolved and adversaries have learned more about how to develop them. Such an attack could be carried out by rogue states or terrorists. Several countries already have, or could soon acquire, EMP-strike capabilities. A determined adversary can achieve this capability without having a high level of sophistication.

Today, North Korea has the capability to execute EMP attacks. This reality has been made clear by its possession of nuclear weapons, estimated to number 60. Moreover, it possesses the requisite delivery systems including missiles with intercontinental ranges capable of striking targets in the continental United States. It is also reported that North Korea has tested nuclear weapons specifically designed to enhance EMP effects and that such attacks are an integral part of its military planning and doctrine.[xii]

Further substantiating this capability is the fact that North Korea (and Iran) launches satellites to the south where they approach the United States from our mostly undefended south. For example, in 2012 and 2016 North Korea launched satellites orbiting in a southern trajectory that regularly passed over the United States.[xiii]

If an adversary's satellite was secretly outfitted with a nuclear weapon it could be detonated in space over the United States producing EMP with devastating consequences.[xiv] Neither ablative shielding to protect the satellite-launched nuclear device or an accurate guidance system would be necessary to accomplish an EMP attack above the atmosphere as would be the case, for example, to enable a nuclear warhead to reenter the atmosphere to strike a U.S. city. Since the United States currently lacks robust early-warning radar coverage in the southern hemisphere, a satellite concealing a nuclear weapon and traversing a southern trajectory could blindside the United States.

Iran is reported to have tested whether its ballistic missiles could be detonated by remote control while still in high-altitude flight. A plausible explanation for such tests is that Tehran is developing the capability to explode a high-altitude nuclear EMP weapon. In addition, the 2008 EMP Commission Report[xv] stated that in the late 1990s Iran had launched a ballistic missile from a barge in the Caspian Sea and sent electronic signals that suggested it triggered the detonation of a simulated nuclear weapon at an altitude of approximately 249 miles to produce EMP.

On June 17, 2019, Iran announced that it would accelerate production of its allowed enrichment level of uranium (i.e., 3.67 percent) and exceed the stockpile cap permitted under the Joint Comprehensive Plan of Action (JCPOA) nuclear deal by the end of June 2019.[xvi] On July 1, 2019 inspectors from the International Atomic Energy Agency (IAEA) verified that Iran had indeed breached the stockpile limit. Iranian Foreign Minister Mohammad Javad Zarif said the next step would be enriching uranium beyond the 3.67 level.[xvii] IAEA inspectors confirmed on July 8, 2019 that that the country had surpassed the 3.67 percent threshold which constituted another breach of the JCPOA. Iran claimed that these actions were in response to the withdrawal of the United States from the JCPOA last year and its imposition of economic sanctions on Tehran in May 2019.[xviii]

If Tehran continues to violate the JCPOA with increasing levels of uranium enrichment (a 90 percent level is required for nuclear-weapon-grade fuel) it would take approximately one year before it can produce nuclear weapons and possibly mate them to Iran's growing inventory of ballistic missiles: and in so doing, provide it with an EMP-attack capability.

Moreover, terrorist groups, possibly acting as surrogates to North Korea or Iran, could receive/steal nuclear weapons and place them on ballistic missiles (Tehran has supplied its proxies, e.g., the Houthis in Yemen, with missiles and drones to attack targets throughout Saudi Arabia[xix]) that they could launch from vessels near U.S. coasts to undertake an EMP strike without the need for the warhead to reenter the atmosphere.

Both Russia and China have an unambiguous capability to launch EMP attacks. These threats are exacerbated by Russia's nuclear modernization and missile programs, first-use nuclear strategy, and belligerent actions in East Europe and elsewhere; and by China's nuclear and space system modernization and aggressive activities in the South China Sea.

The United States currently possesses ballistic missile defense (BMD) capabilities and assets that can begin providing active defenses to address the EMP threat. These include the U.S. Navy's *Aegis* BMD ships, particularly if positioned in proximity to North Korean launch sites, or if patrolling in the Gulf of Mexico – together with land-based *Aegis* Ashore configurations (ideally outfitted with the previously mentioned SM-3 IIAs) which could be deployed along the Gulf Coast – to counter the southern trajectory and terrorist-ship launched threats. Coupled with our existing ground-based interceptors in Alaska and California, these systems form a nascent layered defense to counter EMP and southern trajectory/terrorist attacks.

However, as will be described in greater detail in the next section, much more needs to be done to confront the EMP and other evolving threats, including improving/augmenting the existing BMD capabilities noted above, together with developing near-term boost-phase intercept capabilities and space-based intercept systems.

Natural Incidents of EMP

EMP can also be generated by natural occurrences such as solar storms. The sun produces coronal mass ejections (CMEs), which are giant clouds of solar plasma inundated with lines of magnetic fields that are propelled from the sun during strong, long-duration solar flares. A CME – sometimes referred to in the literature as a geomagnetic disturbance or GMD – can blast billions of tons of solar matter outward from the sun's atmosphere. A CME striking the Earth would interact with the Earth's magnetic field to produce powerful electromagnetic fluctuations. At its most active, the sun can produce two or three CMEs a day.
On September 2, 1859, the largest solar storm ever recorded propelled an intensely powerful CME directly at Earth. This CME, referred to as the Carrington Event (named after the British astronomer Richard Carrington who first observed the CME), destroyed telegraph systems, the most advanced technology of its day, and touched off fires in the Northern Hemisphere and in Europe. Fortunately, most people experienced the Carrington Event as little more than a light show caused by the intense auroras that illuminated the skies around the world.

Technology was not nearly as sophisticated and indispensable to human life in 1859 as is currently the case. Today, a Carrington-like event would cause devastation on our electronic-dependent society, burning out transformers which regulate the electrical currents that power almost all devices. After overwhelming the Earth's protective magnetic field, it could disable/destroy satellites, power grids, and other critical infrastructure. We would have to deal with the simultaneous loss of much, if not all, of the electric power grid, satellite-delivered telecommunications, radio and over-the-horizon radar, and the Global Positioning Satellites (GPS). With the GPS guidance inoperable, aircraft around the world would likely be grounded.

A present-day CME, like a man-made nuclear EMP event, would have cascading effects on our space- and ground-based critical infrastructures. Modern civilization would be severely disrupted as the technologies and systems that support and enable human life were disabled/destroyed by the enormous electromagnetic force of the CME. The result would be the loss of trillions of dollars and widespread death. For example, according to a U.S. government study, a powerful CME event would cause $2 trillion in damage in the first year alone and take 4 to 10 years to recover.[xx]

A solar storm in 1989 knocked out power in Canada's Quebec province, and another in 2003 left millions of people in the dark for 12 hours in eight U.S. states and in Ontario.[xxi] Earth witnessed a near-miss CME event on July 23, 2012 when a succession of coronal mass ejections sped through Earth's orbit. According to U.S. scientists, this CME was so powerful that it rocketed approximately 93 million miles reaching Earth's orbit in only 19 hours. If it had arrived nine days earlier it would have made a direct impact on Earth resulting in severe devastation.[xxii]

Most CMEs speed harmlessly through space; approximately 30 hit Earth every year with the majority deflected off the planet's atmosphere. There is a 12.3% chance every decade of a Carrington-like event taking place. However, NASA solar scientists state that although the probability of a massive CME directly hitting Earth is low, "it could happen at any time … and if it does the results could be catastrophic to modern human society."[xxiii]

President Trump's EO states that the United States must undertake efforts to maintain the sustainability and rapid reconstitution of the U.S. electric grid and other ground- and space-based critical infrastructure to guard against the devastating impact of a naturally-occurring EMP event.

Maintaining the Momentum of the EMP Executive Order and Overcoming Impediments

As noted in an important article following the release of President Trump's EMP document, the EO order represents a unique "opportunity for the U.S. government and private sector to achieve national EMP preparedness quickly, within two to three years."[xxiv] As described above, the EO mandates a whole-of-government effort to address the EMP threat including near-term studies to identify, among other issues, the most vulnerable U.S critical infrastructure and technology options to increase resiliency to EMP.

The fact that the EO also directs DOD to "defend the Nation from adversarial EMPs originating outside of the United States through defense and deterrence …"[xxv] is also an extremely important development. It means that deterring and defending against man-made EMP attacks should become an unequivocal and long past due DOD mission leading to specific missile defense and related capabilities and plans to counter the EMP threat.

As outlined in our April 2019 *IFPA Update* as well as in earlier *Updates* covering missile defense and EMP,[xxvi] the United States should take several steps regarding active defenses against man-made EMP threats.

The United States should fast-track development of a near-term boost-phase intercept (BPI) capability using the existing sensor and battle management and communications capabilities of the F-35 aircraft and equipping it with an upgraded/modified or new interceptor missile. BPI is *the* most effective counter to the EMP threat (and to any type of ballistic missile threat for that matter) because it destroys a ballistic missile shortly after takeoff before it can release its nuclear warhead(s) and possible decoys.

Interception of a warhead in the later stages of its midcourse flight may, in some attack scenarios, be too late given that an EMP warhead or satellite could be detonated at an earlier point during its midcourse flight before U.S. systems can engage it. Terminal defenses would not have any capability of countering an EMP attack detonated in the midcourse. Currently, the U.S. missile defense architecture contains only midcourse and terminal systems.

The optimum solution to combating the EMP threat (and all ballistic missile threats) would be development and fielding of a space-based intercept layer which would provide defense coverage in all phases of a ballistic missile's flight, but most importantly in the boost-phase. The January 2019 MDR directs DOD to conduct a 6-month analysis to determine the feasibility of a space-based boost-phase defense. This analysis should include the *Brilliant Pebbles* space-intercept concept. The *Brilliant Pebbles* concept was based on a proven operational capability that underwent several scientific and engineering reviews in the 1989-90 timeframe.

After a thorough cost evaluation in 1989 it was determined that the price for a constellation of 1000 *Brilliant Pebbles* was $11 billion spread over a twenty-year span. Today, adjusted for inflation, the price would be $23.09 billion. Its cost could be even less now, and its operational capabilities greater, given the technological and cost-saving advances made in the defense and commercial sectors since 1989. A 21st-century *Brilliant Pebbles* architecture would provide robust defense against EMP attacks. It would also bolster deterrence by denial, increase escalation control options for U.S. decision makers, and help reverse the offense/defense cost-exchange ratio currently favoring the offense.

In addition, the United States should accelerate testing the U.S. Navy's Standard Missile (SM)-3 IIA interceptor missile to establish whether it can defend against ICBMs. The MDR called for testing this capability in 2020. An SM-3 IIA capable against ICBMs could be deployed in a land-based *Aegis* Ashore configuration along the U.S. Gulf Coast to counter the southern trajectory and terrorist-ship launched EMP threat.

On a related issue, the EO also correctly directs the Secretary of Defense to "conduct R&D and testing to understand the effects of EMPs on Department of Defense systems . . . and develop technologies to protect Department of Defense systems and infrastructure from the effects of EMPs to ensure the successful execution of Department of Defense missions." This directive underscores the reality that the majority of DOD's infrastructure is dependent on the national grid and other vulnerable U.S. critical networks. Consequently, an EMP event could severely curtail the ability of the U.S. military to carry out its missions.

A possible impediment to the momentum and implementation of the Executive Order, however, is that efforts to address the EMP problem could get bogged down by bureaucratic inertia and lobbyists who have long ignored the EMP problem or worked to underestimate its impact, in some cases even falsifying data and test results.

For example, according to three EMP experts, one of the greatest obstacles to realizing successful EMP preparedness is "buck-passing by the Department of Homeland Security (DHS), Department of Defense (DOD), Department of Energy (DOE), and utilities. No one wants to take the lead on protecting critical infrastructures from EMP, and everyone has plausible arguments why responsibility belongs to someone else."[xxvii]

Another concern is stringing out and slow-rolling EMP studies and evaluations. For example, the October 2018 *National EMP Strategy* drafted by DHS would, in contrast to President Trump's EO, have continued studying EMP until 2028.[xxviii] This is why it is critical that President Trump's EO established leadership of the EMP initiative within the National Security Council at the White House, seeks a whole-of-government solution, and has established well-defined, near-term reporting deadlines.

A related issue is that several EMP studies have arrived at spurious findings. One, the 2017 Report by the Electric Power Research Institute (EPRI),[xxix] concluded that only a limited number of bulk-power electric transformers would be at risk of damage following an EMP attack. This conclusion resulted because EPRI used calculations for nuclear field strengths significantly lower than would actually be generated in the EMP scenarios EPRI examined. The EPRI Report also underestimated the field strength of a natural EMP occurrence.

More recently, at The Electromagnetic Defense Task Force Summit held in April 2019 at the Air University, Maxwell Air Force Base, in Alabama, several attendees criticized a recently published EPRI report that attempted to minimize the possible impacts of EMP attacks and Carrington-like events.

For example, Dr. Peter Pry, who was part of the EMP Commission, said "EPRI's EMP report is obviously a last-ditch effort to derail the recent White House executive order on coordinating national resilience to electromagnetic pulses that would fast-track protecting the national electric grid and other life-sustaining critical infrastructures from EMP threats." Pry added that

EPRI's report "should be accorded no more credibility than the independent laboratory analyses funded by the cigarette industry in the 1950s falsely claiming there is no causal link between smoking and lung cancer."[xxx]

Yet another issue that can hamper implementation of the EMP EO is the lack of coordination and EMP data sharing among government agencies and with the private sector. For example, in many cases, the data used and results of classified EMP studies undertaken by DOD are not made available. Therefore, subsequent studies by other government agencies or non-government entities are conducted using inaccurate data, particularly regarding nuclear field strengths. Not being able to share data and study finding/conclusions also hampers electric power companies and other critical infrastructure companies from understanding the EMP threat and the need to harden systems.

As was the case with the EPRI Report cited above, one of the main reasons EMP studies commonly produce flawed findings is because erroneous (far too low) field strengths are utilized in calculating the effects of EMP attacks and consequently the destructive impacts of an EMP event are significantly underestimated. At times, this is because of bias (electric utilities and operators do not want to incur the costs to harden critical infrastructure), other times because the studies were conducted without access to classified data on EMP effects, and sometimes due to a combination of both factors.

President Trump's EO may loosen the logjam on coordination and data sharing within the government and with the private sector. For example, the EO states that the Secretary of Defense will:

- "share technical expertise and data regarding EMPs and their potential effects with other agencies and with the private sector, as appropriate;"

Hopefully, this directive will help facilitate the transfer of accurate EMP data and expertise among government and non-government stakeholders resulting in more accurate, unbiased studies and assessments.

To keep President Trump's EO on track, the ongoing support and oversight from the White House is vital. The White House must hold stakeholders in government departments/agencies and in the private sector accountable to ensure successful implementation of the initiative and to prevent it from becoming mired in bureaucratic inertia, slow-rolling by entrenched opposition, and lobbying. Supporters in Congress in the committees and subcommittees who have responsibility for the U.S. critical infrastructure and EMP-related issues must also provide oversight and pass legislation where necessary to advance the goals of the EO.

Conclusions

President Trump's March 2019 EMP Executive Order is the first comprehensive government-wide policy to protect the nation against naturally-occurring and man-made EMPs. Either class of EMP event could render the U.S. infrastructure inoperable, cripple society, and result in millions of casualties.

The EO mandates several immediate actions and studies to protect critical infrastructure, key systems, and networks most at risk from EMP. It is designed to increase preparedness against EMP events through enhanced public and private coordination and planning. The EO places the White House in charge of this effort.

The EO directs DOD to deter and defend man-made EMP attacks. This represents the first time EMP deterrence and defense against man-made EMP is explicitly stated to be a defined mission of the U.S. military.

The most effective approach to combat man-made EMPs is via boost-phase intercept. Consequently, the United States should:

- Develop/field a near-term BPI capability based on the F-35 aircraft;
- Develop/field a space-based-intercept layer drawing on the *Brilliant Pebbles* space-intercept concept, an operational capability proven in 1989-90 timeframe; and,
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To sustain the momentum of the President Trump's EO, uninterrupted support and management from the White House is essential. The White House must hold the feet of stakeholders in government departments/agencies and in the private sector to the fire in order to ensure implementation of the initiative and to forestall it becoming bogged down by bureaucratic inertia, slow-rolling by entrenched opposition, and lobbying. Supporters in Congress in the committees and subcommittees who have responsibility for the U.S. critical infrastructure and EMP-related issues must also provide oversight and pass legislation where necessary to advance the goals of the EO.

Endnotes

[i] David E. Sanger and William J. Broad, "Trump Inherits a Secret Cyberwar Against North Korean Missiles," *New York Times*, March 4, 2017. See https://www.nytimes.com/2017/03/04/world/asia/north-korea-missile-program-sabotage.html.

[ii] "Executive Order On Coordinating National Resilience to Electromagnetic Pulses," The White House, March 26, 2019. See https://www.whitehouse.gov/presidential-actions/executive-order-coordinating-national-resilience-electromagnetic-pulses/.

[iii] The EMP Commission was created in the Fiscal Year 2001 National Defense Authorization Act to identify steps that should be taken by the United States to better protect its military and civilian systems from EMP attacks. Its charter was continued in the FY2016 NDAA. The EMP Commission completed its information-gathering in June 2017 and subsequently produced several important reports and studies.
[iv] The Independent Working Group on Missile Defense was formed in 2002. Its goals are to: identify the evolving threats to the United States, its overseas forces, allies, and coalition partners from the proliferation of ballistic missiles and nuclear weapons including electromagnetic pulse (EMP) capabilities; examine missile defense requirements in the current security setting; assess current missile defense programs in light of technological opportunities; and set forth general and specific recommendations for a robust, layered missile defense for the United States to meet these proliferation challenges.
[v] A complete list of EMP Commission publications can be found at http://www.firstempcommission.org/. For IWG/IFPA publications see http://www.ifpa.org/research/currentResearch.php and http://www.ifpa.org/archives/archivePublications.php.
[vi] "Executive Order On Coordinating National Resilience to Electromagnetic Pulses."
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[viii] "The 2019 Missile Defense Review," Office of the Secretary of Defense, January 2019. See https://www.defense.gov/Portals/1/Interactive/2018/11-2019-Missile-Defense-Review/The%202019%20MDR_Executive%20Summary.pdf.
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The Institute for Foreign Policy Analysis
http://www.ifpa.org

Robert L. Pfaltzgraff, Jr., President
RLP@ifpa.org
Jack Kelly, Senior Staff
kell@ifpa.org

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Institute for Foreign Policy Analysis, PO Box 390960, 770 Massachusetts Ave., Cambridge, MA 02139