Threat of Cascading "Permanent Blackout" Effects and High Altitude Electromagnetic Pulse (HEMP)*

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Abstract

There is growing concern over permanent blackouts caused by high altitude electromagnetic pulse (HEMP) generated from a high-altitude nuclear explosion (HANE). Despite being a type of nuclear attack, the issues raised by HEMP attacks and specific measures against them have been absent from the discourse on international security policy, and unaddressed in past nuclear disarmament and non-proliferation efforts. With proliferation of nuclear weapons remaining unchecked in today's security environment, this article argues for the necessity to examine measures against HEMP attacks and against cascading blackout effects. Furthermore, it calls on the international community to reach a shared understanding that the threat of HEMP is a humanitarian issue of nuclear weapons, and to create international norms that prohibit HEMP attacks.

Introduction

In recent years, particularly in North America, increasing attention has been paid to the cross-disciplinary security issue of high altitude electromagnetic pulse (HEMP) generated from a high-altitude nuclear explosion (HANE), as well as electromagnetic pulse (EMP) generated by high power microwave (HPM) devices that is non-lethal but can cause irreversible damage to electronics. Specifically, the potential risk of an adversary executing a HEMP attack as a means of asymmetrical nuclear attack is starting to be recognized amid societies' rising dependence on advanced information and electrical infrastructure. The media too has begun to sound alarm bells over the risk in various manners.[1]

In parallel with this, the possibility of localized EMP attack by terrorists, criminals, and other individuals has been a subject of widespread international concern.[2] HPM devices are sold inexpensively on the market, and information on making and using them proliferate on the web. Additionally, EMP interference arising from a natural phenomenon has stark consequences. In terms of larger EMP events, it has been found that a coronal mass ejection that turns into a solar

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1 Dan Vergano, "One EMP Burst and the World Goes Dark," *USA Today*, October 27, 2010; Allison Barrie, "EMPs: How to Detect a Blast that Could Darken the World," *Fox News*, January 14, 2014; Sharon Weinberger, "The Boogeyman Bomb: How Afraid Should We Be of Electromagnetic Pulse Weapons?" *Foreign Policy*, February 17, 2010.

2 Michael F. Maloof, *A Nation Forsaken – EMP: The Escalating Threat of an American Catastrophe,* Washington, D.C.: WND Books, 2013, pp.8-11.

storm and reaches the surface of the Earth leads to EMP interference. In fact, the blackout that occurred in Quebec Province, Canada in March 1989 is considered an outcome of a solar storm.[3] As regards the solar storm of July 2012, the National Aeronautics and Space Administration (NASA) has announced that the Earth was spared from a direct hit by this solar storm, which could have caused EMP interference leading to a massive blackout large enough to take modern civilization back in time.[4] "Blackout" here refers not to a temporary and localized power outage, but to a large-scale permanent blackout in which EMP irreversibly knocks out a range of electrical and communication infrastructure across a wide area. Observers have noted that the damage would be magnified with cascading effects, beginning with the collapse of many electrical and communication infrastructure and other critical social infrastructures that utilize the supervisory control and data acquisition (SCADA) systems that are weak against EMP.[5] That the damages cover a wide area means a considerably long lead time is required for relief work and recovery of service to begin. Further, it implies that due to irreversible infrastructure damages, electricity service will not be restored basically until malfunctioning power grid and power transmission infrastructure components have been replaced and repaired. This is seen as a real and serious threat in the United States, where in 2005, the security situation deteriorated significantly over a mere few days in areas where electricity service stopped because of Hurricane Katrina's effects. It is feared that a permanent blackout that covers a wide area would increase the ripple effects of electricity shutdown and communication disruption as time passes, shutting down telephone service, railway transport, radio communication, computer systems, transport networks, supplies of water and fuel, and commerce and trade, resulting in a serious situation with direct impacts on the lives and property of the people.[6]

It is suggested that in North America this shared awareness of the EMP threat was formed from experiencing several blackout events from natural disasters, such as the New York City blackout of some years ago and Hurricane Katrina more recently, which has raised awareness of the potential risks facing a society highly dependent on information and electrical infrastructure.[7] Irrespective of whether this was a direct or indirect experience and regardless of what factors were behind the electrical infrastructure problems, it is generally becoming easier to predict damages that may occur if the North American power grid were disrupted over a long duration. As a matter of fact, we are beginning to see the EMP threat (E) newly included in discussions of the existing concept of managing risks attributable to chemical, biological, radiological, nuclear, and explosives (CBRNE).[8] Because CBRNE requires crosscutting efforts by a variety of first responders, including police, fire department, medical service, military, and local governments, these elements have

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3 Ibid., pp.53-54.

4 "Near Miss: The Solar Superstorm of July 2012," National Aeronautics and Space Administration website, July 23, 2014, http://science.nasa.gov/science-news/science-at-nasa/2014/23jul_superstorm/.

5 Maloof, *A Nation Forsaken – EMP: The Escalating Threat of an American Catastrophe*, pp.33-35.

6 Tilman A. Ruff, "The health consequences of nuclear explosions," ed., Beatrice Fihn, *Unspeakable Suffering: The Humanitarian Impact of Nuclear Weapons*, Reaching Critical Will, 2013, http://www.reachingcriticalwill.org/images/documents/Publications/Unspeakable/Unspeakable.pdf, p.20.

7 James Jay Carafano and Richard Weitz, "EMP Attacks: What the U.S. Must Do Now," *Backgrounder*, no.2491, November 17, 2010, http://thf_media.s3.amazonaws.com/2010/pdf/bg2491.pdf, p.2.

8 Michael F. Maloof, "Understand EMP Threat? U.S. Enemies Do," *CBRNE Terrorism Newsletter*, vol.47, 2013, http://www.cbrne-terrorism-newsletter.com/resources/2013_1%20Dirty%20News.pdf, pp.2-6.

made it difficult to incorporate CBRNE into the discourse on international security theory. In addition, like CBRNE, the threat of EMP, as a component of its risk, constitutes a grave issue whose causes extend over too large a scope to discuss within the logic of security study alone (natural phenomenon: solar storm; nuclear attack: HEMP; military attack by conventional forces / terror attack: HPM [elaborated later in this article]). In addition, it is essential that interdisciplinary expertise is consolidated and examined, in order to take account of the repercussions of EMP's damages due to their cascading effects on the increasingly complex communication, electrical, and various social infrastructures generally found in major industrialized countries today, and of the approaches for addressing them.

On this basis, this article distills solar storm, HANE, and HPM, respectively, in order to understand the various aspects of the EMP threat. In particular, the mechanism of EMP production is outlined, with a focus on HEMP which merits attention in the context of national security in light of the extensiveness of the anticipated damages. This article then discusses EMP threats and their anticipated damages based on considerations made in previous studies. This is followed by a multi-perspective examination of the state of proliferation of HEMP attack capabilities, the concept of deterrence against HEMP attacks and measures against them, and disarmament and non-proliferation approaches.

1. Today's EMP Threat

Today, the EMP threat can be broadly divided into three categories: solar storm (natural phenomenon); HEMP generated from HANE (nuclear weapon); and HPM (conventional weapon). While thunder also generates EMP according to the technical definition of "emitted high-power electromagnetic pulse," thunder is omitted for the purposes of this article given that various measures are being taken due to the high frequency at which the associated damages occur.[9] This article first examines the threat of HANE and HEMP that carry the most interest as topics of study in international security theory.

(1) HANE and HEMP: Their historical background

Observers say EMP generated by nuclear explosion was already forecasted by Enrico Fermi as of Operation Trinity, the world's first nuclear test conducted in the United States in 1945, when, because of his forecasts, all measurement-related electronic equipment were shielded to protect them from EMP. In addition, the U.S.-Britain joint nuclear test in 1958 is said to have studied the vulnerability of nuclear weapons to EMP and how to strengthen their survivability.[10] Meanwhile, *The Effects of Nuclear Weapons* report compiled by the U.S. Department of Defense and the Energy Research and Development Association in 1977 describes that HEMP effects from a nuclear explosion went hardly noticed in the 1940s, that malfunction of electrical equipment in the vicinity of nuclear test sites finally began to gain recognition in the 1950s, and that around

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9 Technical Study Expert Committee on Electromagnetic Environment and Information Security, The Institute of Electrical Engineers of Japan, ed., *Denjiha to Jōhō Sekyuriti Taisaku Gijutsu* [Electromagnetic Wave and Information Security Technology], Tokyo: Ohmsha, 2012, p.34.

10 Carl E. Baum, "System Design and Assessment Notes 32: From the Electromagnetic Pulse to High-Power Electromagnetics," *Proceedings of the IEEE*, vol.80, no.6, June 1992, http://www.ece.unm.edu/summa/notes/SDAN/0032.pdf, pp.789-790.

1960 the vulnerability of many electrical equipment—both military and civilian—to HEMP was understood clearly.[11]

Many of the nuclear tests conducted by major nuclear-weapon states were atmospheric tests until the Partial Test Ban Treaty (PTBT) of 1963 entered into force. It is said that the United States came to understand the actual physical effects of HEMP by Operation Starfish Prime, which detonated a nuclear weapon at approximately 400-km (248-mile) altitude over the Pacific, 1,400-km away from Hawaii.[12] EMP drew attention also as a means of missile defense in the early 1960s when the U.S.-Soviet missile gap debate was drawing to a close. Operation Starfish Prime did a technical study of whether emitting vast quantities of free electrons produced by HANE in Van Allen radiation belts can destroy, directly in airspace, a nuclear warhead flying from an adversary country. In testimonies to Congress in the first half of the 1980s, Edward Teller, known as one of the fathers of nuclear weapons in the United States, does indeed explain HEMP effects not only from the offensive but also from the defensive perspectives.[13]

The series of atmospheric nuclear tests the United States conducted in 1962, epitomized by Operation Starfish Prime, included the use of a hydrogen bomb at approximately 1,040-km altitude (650-mile altitude; nearly the same altitude as a space shuttle orbit). At that instant, a blackout occurred in a city area approximately 3,360-km (2,100-mile) to the northeast. Some regard that this in turn prompted the United States and the Soviet Union to conclude the PTBT in 1963 as an attempt to contain the threat of HEMP.[14]

Operation Starfish Prime was one of the 36 nuclear tests conducted under the name of "Operation Dominic." Operation Dominic consisted of: 29 airdrop tests of newly designed nuclear weapons; 5 launch tests of rockets carrying nuclear warheads to gather data on the use of nuclear warheads at high altitudes; and operational tests of nuclear weapon systems—a Polaris submarine-launched ballistic missile and an ASROC anti-submarine rocket were test fired, respectively.[15] In the airdrop test category, Operation Fishbowl was conducted, which detonated Thor missiles carrying high yield nuclear warheads at high altitudes between 48 and 400 km (between approximately 30 and 248 miles) to evaluate their destructive power and level of effect on an adversary's approaching ballistic missile. These series of tests were the last airdrop tests carried out by the United States and produced extremely high yield equivalent to 8.3 Mt. They included the Housatonic test on

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11 Samuel Glasstone and Philip J. Dolan, eds., *The Effects of Nuclear Weapons (Third Edition),* Washington, D.C.: U.S. Department of Defense and Energy Research and Development Association, 1977, p.514.

12 Mark Schneider, "The Emerging EMP Threat to the United States," *National Institute Press*, November 2007, http://www.nipp.org/National%20Institute%20Press/Current%20Publications/PDF/EMP%20Paper%20Final%20November07.pdf, p.1.

13 Charles B. Stevens, "Mastering EMP for Offense and Defense," *Executive Intelligence Review*, vol.10, no.27, July 19, 1983, http://www.larouchepub.com/eiw/public/1983/eirv10n27-19830719/eirv10n27-19830719_033-mastering_emp_for_offense_and_de.pdf, p.33; Edward Teller, "Dr. Edward Teller Explains the Need for Antiballistic-Missile Defense (Conference minutes of the Georgetown University Forum on Anti-Missile Beam Weapons on January 18, 1983)," *Executive Intelligence Review*, vol.10, no.5, February 8, 1983, http://www.larouchepub.com/eiw/public/1983/eirv10n05-19830208/eirv10n05-19830208_054-dr_edward_teller_explains_the_ne.pdf, pp.54-57.

14 Scott W. Merkle, "Non-Nuclear EMP: Automating the Military May Prove a Real Threat," Federation of American Scientists Military Intelligence Professional Bulletin, http://www.fas.org/irp/agency/army/mipb/1997-1/merkle.htm.

15 Nuclear Weapons Archive, "Operation Dominic 1962 - Christmas Island, Johnston Island, Central Pacific," http://nuclearweaponarchive.org/Usa/Tests/Dominic.html.

October 30, 1962 that conducted a high altitude explosion at 3,697-km altitude, and Chama test that caused a 1.59 Mt free-fall nuclear explosion at 3,648-km (11,970-ft) altitude.[16]

In Operation Starfish Prime, a Mark-49 nuclear warhead placed on a Thor missile was detonated at an altitude of approximately 400 km above Johnston Island in the Pacific, producing a yield of 1.45 Mt—a very large yield for an atmospheric nuclear test conducted by the United States. HEMP generated by this nuclear explosion affected electrical systems in the Hawaiian Islands 1,400 km away. In these islands, street lighting went out, circuit breakers of buildings were tripped, falsely triggered burglar alarms of houses rang, and a telecommunications relay facility was damaged.[17]

At around the time of Operation Starfish Prime, President John F. Kennedy reportedly renewed his determination to ban atmospheric nuclear tests, given the growing U.S. public sentiment against fallout associated with such tests, coupled with concerns over the increasing risks that radiation exposure posed to the health of astronauts and others. At the same time, there were also proponents in the United States for increasing electrons in the Van Allen belts through nuclear explosions in the upper atmosphere, and thereby, bringing down an adversary's approaching nuclear warhead in the upper atmosphere, as was discussed earlier. Michael Krepon suggests that amid these two conflicting views, President Kennedy went ahead with Operation Starfish Prime but decided to enter into PTBT negotiations because of various considerations, including: the health risk concerns noted above; considerations about HEMP's impacts on satellites, communication links, and the military force's command and control; as well as the risk of ultimately having to rely much on missile defenses in the worst-case scenario of U.S.-Soviet Union nuclear exchanges.[18]

At this same timing in 1962, the Soviet Union also conducted the atmospheric nuclear test, "Test 184," above a nuclear test site in Kazakhstan, and HEMP effects were allegedly observed in various places.[19] The HEMP effects allegedly observed in the places included surge protector burnouts and power supply breakdowns in the periphery of the nuclear test site, and damage to overhead and underground buried cables across a 600 km-distance. Since then, the Soviet Union reportedly took measures to increase the survivability of their military and civilian infrastructure against HEMP attacks.[20]

(2) The mechanism for HEMP production

The mechanism for HEMP production is explained in previous research basically as follows. First, the gamma rays emitted by HANE and neutrons interact with the water molecules and atoms in the air by the "Compton effect," and create an ionized area surrounding the burst point. At this instant, the negatively charged electrons separate instantaneously from the heavy positively

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16 Ibid.

17 EMP Commission, "Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack Volume 1: Executive Report," 2004, http://www.empcommission.org/docs/empc_exec_rpt.pdf, p.4.

18 Michael Krepon, "Analysis: How Not to Test in Space," Stimson Center website, November 7, 2011, http://www.stimson.org/summaries/how-not-to-test-in-space-/.

19 EIS Council, *Report: USSR Nuclear EMP Upper Atmosphere Kazakhstan Test 184*, http://www.eiscouncil.org/ICMDroot/images/upload/media/Soviet%20Test%20184.pdf.

20 Clay Wilson, "High Altitude Electromagnetic Pulse (HEMP) and High Power Microwave (HPM) Devices: Threat Assessments," *CRS Report for Congress*, July 21, 2008, p.18.

charged ions. As a result, an electric field is created in around 10-8 second. This electric field strength decreases in a very short period of time. Although the duration of the pulse is short, it produces high-power energy. While it also depends on the size of the nuclear warhead detonation, energy is radiated from the burst point at the speed of light, similar to various electromagnetic waves, and collected by metallic and other electrical conductors at some distance. The radiated energy becomes extremely strong electric currents and high voltages and cause severe damages to electrical equipment connected to metal and electrical conductors.[21]

According to a report released by the EMP Commission in 2004,[22] HEMP, which presents the most serious concern for security, is generated as a result of the detonation of a nuclear warhead at altitudes between 40 km and 400 km above the Earth's surface. EMP is considered to consist of three components: E1; E2; and E3. Specifically, the first component of EMP, i.e., E1, is a free-field energy pulse with a rise-time measured in a very short timeframe of a billionth to a few billionths of a second. E1 is the electromagnetic shock that temporarily disrupts or damages the functions of control systems using electronic bases, sensors, communication equipment, protective equipment, computers, and other devices. These disruptions or damages occur and manifest simultaneously over a large area geographically. Secondly, the second component of EMP, or the middle component E2, has a lightning-like effect in the same geographic area as E1. While it is more geographically widespread than E1, its amplitude is weaker. Normally, the impacts of E2 are not an issue for critical infrastructure systems made with lightning damages in mind. However, if EMP's first component E1 and E2 have synergistic effects, they could impair and destroy protective and control systems. This is because E2 enters the system and causes failure following the damages resulting from E1. Lastly, the third component of EMP, E3, is a slow-rising, long- duration pulse that creates disruptive currents in long electricity transmission lines, resulting in damage to electrical supply and distribution systems connected to the lines. The sequence of E1, E2, and E3 is important in the sense that not only does each cause damage respectively, but the later damage is further compounded by the damage in the previous phase.[23] In the "*Comprehensive Study on Nuclear Weapons*" Report of the United Nations Secretary-General of 1980 (A/35/392, September 12, 1980), published also into Japanese, "The electromagnetic pulse and its effects" illustrates HEMP effects that are generated when a HANE occurs at an altitude of 100 km above Moscow. Furthermore, the report notes that with HANE up to an altitude of 10 km to 15 km, the strength of the EMP on the Earth's surface decreases with increasing altitude of detonation, and that a strong EMP will again reach the ground at higher altitudes due to the relationship between atmospheric density and geomagnetic field variation. The report states that HANE at an altitude of 80 km would produce EMP effects over a circular area with a radius of approximately 1,000 km on the ground and an altitude of 160 km would produce effects over a circular area with a radius of approximately 1,500 km.[24]

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21 Glasstone and Dolan, eds., *The Effects of Nuclear Weapons (Third Edition)*, pp.515-516.

22 EMP Commission, "Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack Volume 1: Executive Report," p.4.

23 Ibid., pp.5-6.

24 *Kakuheiki no Hōkatsuteki Kenkyū: Kokuren Jimusōchoō Hōkoku* [Report of the United Nations Secretary-General: Comprehensive Study on Nuclear Weapons], trans., Manabu Hattori, Tokyo: Rengo Shuppan, 1982, pp.191-192.

2. EMP Threats and Their Anticipated Damages

(1) Threat of EMP other than HEMP

HEMP, discussed in the previous section, is not the only EMP threat we face today. There exist various variations of threats, and a number of patterns can be discerned, ranging from naturally occurring threats, to the threat of EMP terror attack and state-to-state EMP attacks. The section below examines the threat of EMP other than HEMP.

Radio frequency (RF) weapons that produce HPM are conventional weapons that have been utilized in recent years, for example, in the Iraq War. RF weapons for military uses are said to include electronic circuit destruction ammunition, which are carried on aircraft and discharged above buildings housing the electrical equipment targeted for destruction, and oscillate and irradiate gw microwave impulse signals from a special RF generating tube in the warhead.[25] In the United States, some argue that the country should develop conventional weapon-type no-yield clean EMP weapons that would terminate any attack, as a new means of supplementing U.S. nuclear deterrence.[26]

Meanwhile, it is known that today, there are suitcase-size RF weapons that can be assembled inexpensively by terrorists and criminals. In addition, it is considered sufficiently possible to misuse medical equipment dual-use technology—for example, shock pulse generator for lithotripsy—and thereby, remotely destroy computers and integrated circuits.[27] In regard to the former, there is a famous proving test conducted by Shriner Engineering in 2001 at the request of the U.S. Department of Defense, which studied the extent to which handmade RF weapons could become a threat in reality. The test revealed that an RF weapon with a 1.8 gw-class HPM output can be made relatively easily at a cost of only around US$400.[28] It is thought that by mounting HPM-generating RF weapons onto vehicles, and for example, by simply switching them on in secrecy in the periphery of such locations as an air traffic control tower or the financial district, the weapons can cause localized destruction of PCs and server data and interrupt online commercial transactions, or disrupt communication and lighting systems. Several terror and criminal incidents involving the use of RF weapons have been reported, and the presence of localized EMP threats posed by these weapons are being discussed as part of crime prevention and counter-terrorism measures.[29]

In terms of naturally occurring "EMP interferences," previous studies in this field have frequently made reference to the solar storm which struck Quebec, Canada in 1989 and shut down the entire power grid in this region. In the Quebec case, the generation of a powerful E3 pulse with a magnetic field intensity of 480 nT/min completely destroyed the power grid that had functioned normally until then, in a mere 92 seconds.[30] Fortunately, the international community has so far not experienced a massive solar storm that would take civilization back in time. Unlike EMP threats posed by the aforementioned HEMP and RF weapons, however, solar storm is a natural

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25 The Institute of Electrical Engineers of Japan, ed., *Denjiha to Jōhō Sekyuriti Taisaku Gijutsu*, pp.40-41.

26 Rachel Oswald, "U.S. Should Pursue Nuclear EMP Weapon: Ex-Lab Head," *Global Security Newswire*, February 20, 2013.

27 Maloof, *A Nation Forsaken – EMP: The Escalating Threat of an American Catastrophe*, pp.8-10.

28 Ibid., p.11.

29 Ibid., p.94.

30 EIS Council, *Report: USSR Nuclear EMP Upper Atmosphere Kazakhstan Test 184*, p.4.

phenomenon and, of course, cannot be artificially deterred. For instance, if the powerful solar storm "Carrington flare" that occurred in 1859[31] were to strike the Earth once again, the impacts sustained by today's critical social infrastructure could undeniably be immense and incomparable to those of the 19th century. It is still fresh in our memory that in 2014, the renowned investor Paul Singer warned about solar storms that give rise to terminal damages, saying that a potential massive blackout in North America caused by a solar storm poses an enormous investment risk, and this received significant media attention.[32]

It should be mentioned that alarm bells are also being sounded over potential large-scale blackouts caused by cyber-attacks, which, while not necessarily attributable to EMP, pose significant risks. There is no guarantee that a blackout caused by a cyber-attack would result in limited damages. A media report based on an undisclosed report of the U.S. Federal Energy Regulatory Commission (FERC) explains that the United States has a total of about 100 critical voltage substations, and that destroying nine of their interconnection substations and a transformer manufacturer in the United States would cause a blackout of despairing proportions to the power grid in North America for at least 18 months.[33] Furthermore, in November 2014, Michael Rogers, who concurrently serves as Director of the U.S. National Security Agency (NSA) and Commander of the U.S. Cyber Command, testified at the House Intelligence Committee that China and one or two other countries (Russia according to CNN's speculation) have the capacity to completely shut down the U.S. power grid through a cyber attack.[34] Additionally, already in 2008, a U.S. Central Intelligence Agency (CIA) official was reported as commenting publicly that a cyber attack had caused a blackout in several major cities outside of the United States via the Internet.[35] A matter of deep interest in this regard is the emergency risk report released in 2015 by the well-known U.K. insurance association Lloyd's. The report studies the risk of a cyber attack leading to a massive blackout in North America, and based on a variety of anticipated damage scenarios, estimates the U.S. economic impact to reach from US$243 billion to at most US$1.024 trillion over five years.[36]

It is suggested that this growing alarm over large-scale blackouts with varying causes and contexts has made a full circle and is once again bringing attention to the threats of HEMP and their consequent impacts.[37]

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31 E. W. Cliver and L. Svalgaard, "The 1859 Solar–Terrestrial Disturbance and the Current Limits of Extreme Space Weather Activity," *Solar Physics,* vol.224, 2004, p.408.

32 Kelly Bit, "Elliott Warns of Greatest Danger in Electromagnetic Pulse," *Bloomberg Business*, July 30, 2014, http://www.bloomberg.com/news/articles/2014-07-29/elliott-sees-most-significant-danger-in-electromagnetic-pulse.

33 Rebecca Smith, "U.S. Risks National Blackout from Small-Scale Attack," *Wall Street Journal*, March 12, 2014, http://www.wsj.com/articles/SB10001424052702304020104579433670284061220.

34 Jamie Crawford, "The U.S. Government Thinks China Could Take Down the Power Grid," *CNN Politics*, November 21, 2014, http://www.edition.cnn.com/2014/11/20/politics/nsa-china-power-grid/.

35 Tom Espiner, "CIA: Cyberattack Caused Multiple-City Blackout," *CNET*, January 22, 2008, http://www.cnet.com/news/cia-cyberattack-caused-multiple-city-blackout/.

36 Cambridge Centre for Risk Studies, "Business Blackout: The Insurance Implications of a Cyber Attack on the US Power Grid," *Lloyd's Emerging Risk Report*, 2015, http://www.lloyds.com/~/media/files/news%20and%20insight/risk%20insight/2015/business%20blackout/business%20blackout20150708.pdf, p.21.

37 Sukeyuki Ichimasa, "'Kakuheiki no Jindōteki Eikyō' Rongi to Kōkōdo Denji Parusu (HEMP) Kyōi no Saihyōka" [Reevaluating Threats of High-Altitude Electromagnetic Pulse (HEMP): A New Challenge to the Recent Arguments on Humanitarian Impact of Nuclear Weapons], The Japan Association of International Relations [JAIR] Annual Convention 2015. Sectional Meeting B-5 International Security I, October 30, 2015 report, http://jair.or.jp/upload/2015paper/B05-Ichimasa.pdf, p.11.

(2) The reality of the forecasted EMP damages, with focus on the anticipated damages from HEMP
In principle, whether a large-scale EMP is HEMP or is generated by a solar storm, its effects extend to the air, the Earth's surface, and sea.[38] In the early 1960s, the United States and the Soviet Union came to know about HEMP effects through atmospheric nuclear tests. This was still a time when vacuum tube computers continued to be developed, and computers using integrated circuits (S/360) were finally beginning to be developed along with parametron and transistor-type computers.[39] In space development, this was the period when Soviet astronaut Yuri Alekseyevich Gagarin became the first person in the world to make a single orbit around the Earth on a manned flight on April 12, 1961, and in the following year, 1962, astronaut John Herschel Glenn Jr. became the first person in the United States to make three orbits around the Earth on a manned orbital flight.[40] Electrical and communication networks were already gradually being stretched across, and the use of satellites had begun. Even then, society was not highly networked as it is today. In this regard, in order to analyze what damages would result today from the HEMP effects observed in the atmospheric nuclear tests in the 1960s, analogies inevitably need to be drawn also from blackouts in major cities and other similar events.

As regards a HEMP attack's cascading effects on the power grid and its damages that could spread across a large area, Michael F. Maloof, for example, describes them as "the route back to the 19th century," and warns that society needs to prepare for massive and prolonged blackouts. Specifically, Maloof explains that as a result of EMP damages over a large area: most of today's vehicles and transportation trucks that are mainly electronically controlled will stop moving; fuel supply at gasoline stands will be disrupted, as the electric pump to pump the gasoline up from the underground tank will not be functioning; and pacemakers, estimated to have as many as three million users worldwide, will heat up inside the body and cause physical harm to users. Furthermore, because radio and TV will stop functioning entirely, there will be a considerable decline in the availability of information sought by many people during periods of confusion. Even if broadcasters set aside backup equipment for emergencies, it is self-evident that the fuel for self-generating electricity will run out in a few days. Therefore, it can be expected that if fuel supply runs out for the additional generators, the backup equipment will stop functioning in succession. As for communications, because mobile phones are more vulnerable to EMP than landline phones, most are expected to stop functioning. This implies that people will have no means to contact the police or the fire department in an emergency. Computerized trading systems such as foreign exchange and stock markets will also suffer catastrophic damages. In the worst-case scenario, all online data may disappear together with its backup. Further, with regard to water and food—the most fundamental resources for humans to maintain their life functions, it is anticipated that soon after electrical and transportation infrastructure stop functioning, a vast area will have serious

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38 Federation of American Scientists website, "Nuclear Weapon EMP Effects," http://www.fas.org/nuke/intro/nuke/emp.htm.

39 Akihiko Yamada, "Conpyūtā Kaihatsushi Gaiyō to Shiryō Hozon Jyōkyō ni tsuite: Daiichi Sedai to Daini Sedai Conpyūtā wo Chūshin ni" [History of First and Second Generation Japanese Computers and the Preservation of (Early) Examples], *National Museum of Nature and Science Report on Technology Systematization*, vol.1, March 2001, p.40. http://sts.kahaku.go.jp/diversity/document/system/pdf/003.pdf.

40 Space Information Center, Japan Aerospace Exploration Agency, "Sekai no Uchū Kaihatsu no Rekishi 1960 Nendai" [History of Space Development in the World: 1960s], http://spaceinfo.jaxa.jp/ja/world_space_projects_1960.html.

shortages in both production and distribution.[41]

As regards the above power supplying capability in an emergency, many organizations in industrialized countries are believed to have fuel stock for generating their own electricity for around three days. Whether fuel is supplied in a timely manner after this stock runs out will depend largely on the restoration conditions of the transportation network. This is an issue that no doubt also applies identically to first responders, such as police and fire department, as well as government agencies, medical institutions, transportation services, and companies. Furthermore, the longer it takes to restore these services, the greater the direct impacts on governance. Many previous studies have expressed concerns over the serious impacts of a prolonged blackout on maintaining domestic security, food supply, and medical and health systems.[42]

At the same time, the SCADA system is considered extremely vulnerable to EMP, as was noted at the outset of this article. In general, the SCADA system is utilized widely in major countries in such sectors as power generation including the power grid, production, manufacturing, monitoring control, and communications infrastructure. If these sectors sustain malfunctions or destruction, the estimated cost of their recovery would be considerable, according to a calculation performed based on past SCADA system malfunctions.[43] If all power sources at a nuclear plant are lost irreversibly, this would give rise to the risk of "meltdown," the worst outcome, as was worried following the accident at Fukushima Daiichi Nuclear Power Station in Japan in 2011. In this regard, potential blackouts in areas that have nuclear power plants today are also an issue worth examining.

The 2008 report of the Congressional Research Service (CRS) referred to earlier underscores that the U.S. failure to take EMP measures through years of inaction is making today's EMP threat even more catastrophic.[44] As policy approaches to overcome such inaction, a series of bills have been proposed to the Senate in succession since around 2010, including the Homeland Security Science and Technology Act of 2010 (H.R.4842), the Grid Reliability and Infrastructure Defense (GRID) Act (H.R.5026), and the Secure High-voltage Infrastructure for Electricity from Lethal Damage (SHIELD) Act (H.R.668). Nevertheless, the bills have not been voted on or adopted once, leading to criticisms about the lack of progress made in the actions against the EMP threat in the United States.[45]

3. Responses to HEMP Threats

(1) Proliferation of HEMP attack capabilities

With respect to the accumulation of know-how on HEMP, Scott Stewart and Nate Hughes explain that only the United States and the Soviet Union conducted fewer than 20 atmospheric nuclear tests

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41 Maloof, *A Nation Forsaken – EMP: The Escalating Threat of an American Catastrophe*, pp.61-74.

42 EMP Commission, "Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack Volume1: Executive Report," pp.24-48; Carafano and Weitz, "EMP Attacks-What the U.S. Must Do Now," pp.4-12.

43 Maloof, *A Nation Forsaken – EMP: The Escalating Threat of an American Catastrophe*, pp.33-35.

44 Wilson, "High Altitude Electromagnetic Pulse (HEMP) and High Power Microwave (HPM) Devices: Threat Assessments," http://www.fas.org/sgp/crs/natsec/RL32544.pdf, p.5.

45 James Jay Carafano, Baker Spring and Richard Weitz, "Before the Lights Go Out: A Survey of EMP Preparedness Reveals Significant Shortfalls," *Backgrounder*, no.2596, August 15, 2011, pp.3-5.

at altitudes 20 km or higher, and such data regarding HEMP is extremely limited.[46] While there is little doubt that the five nuclear-weapon states conducted studies on the effects of nuclear weapons, respectively, there is limited public information that shows to what extent know-how on HEMP had permeated. The CRS report notes that: Russia and China had HEMP attack capabilities as of 2004; North Korea is expected to acquire similar capabilities by 2015; and the United Kingdom, France, India, Pakistan, and Israel may acquire HEMP attack capabilities over a few years. The report also expresses concern that Iran, which has repeatedly conducted ballistic missile tests, will acquire HEMP capabilities in the distant future.[47] Furthermore, the CRS report, citing a published source, notes that Russia still has leading physicists carrying out research on electronic warfare weapons and EMP effects.[48] John Foster, former Director of Lawrence Livermore National Laboratory, has also stated that China and Russia may still have EMP attack capabilities even now.[49] On the other hand, according to a 1989 study report of the Natural Resources Defense Council (NRDC), the government and private contractors in France developed an EMP simulator to study measures to defend its nuclear weapons system from EMP, and since the 1970s, have actively studied measures to defend France's missile system against EMP.[50] In connection with France's nuclear assets, Paul Bracken describes that France has an EMP warhead to destroy power grids and communications systems.[51]

As regards other cases, recently it has been noted that North Korea aims to acquire means of conducting HEMP attacks,[52] and concerns have been expressed that this could directly threaten the United States.[53] Some media reports suggest that HEMP attacks utilizing ballistic missiles capable of reaching the U.S. mainland may be considered as an option as a means of making effective use of North Korea's small nuclear weapons stockpile.[54] If a HEMP attack were actually conducted, not limited to North Korea, it could severely impair the operations of satellites in orbit. Because a HEMP attack indiscriminately affects satellites in low orbit, the damages resulting from a HEMP attack would be extremely serious in countries that generally make progressive use of space, whereas an EMP attack overall would have few direct impacts in developing countries that do not make progressive use of space, for example, North Korea. Observers explain that this gives

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46 Scott Stewart and Nate Hughes, "Gauging the Threat of an Electromagnetic Pulse (EMP) Attack," *STRATFOR Security Weekly*, September 9, 2010, http://www.stratfor.com/weekly/20100908_gauging_threat_electromagnetic_pulse_emp_attack.

47 Wilson, "High Altitude Electromagnetic Pulse (HEMP) and High Power Microwave (HPM) Devices: Threat Assessments," pp.16-17.

48 Ibid., p.18.

49 Oswald, "U.S. Should Pursue Nuclear EMP Weapon: Ex-Lab Head."

50 Andrew S. Burrows, Robert S. Norris, William M. Arkin and Thomas B. Cochran, "NWD 89-1: French Nuclear Testing, 1960-1988," *Nuclear Weapons Database Project Working Paper*, February 1989, http://docs.nrdc.org/nuclear/files/nuc_89020001a_87.pdf, p.23.

51 Paul Bracken, *The Second Nuclear Age: Strategy, Danger, and the New Power Politics*, New York: Times Books, 2012, p.238.

52 Nuclear Threat Initiative, "North Korean Military Officer Threatens to Nuke the White House," *Global Security Newswire*, July 28, 2014, http://www.nti.org/gsn/article/north-korean-military-officer-threatens-nuke-white-house/.

53 James R. Woolsey and Peter Vincent Pry, "How North Korea Could Cripple the U.S.," *Wall Street Journal*, May 21, 2013.

54 Peter Vincent Pry, "North Korea EMP Attack Could Destroy U.S.-Now: Obama Must Take Immediate Action," *The Washington Times*, December 19, 2012, http://www.washingtontimes.com/news/2012/dec/19/north-korea-emp-attack-could-destroy-us-now/?page=all.

rise to varying thresholds for conducting a HEMP attack.[55]

(2) Responses and protective measures against EMP threats

This article has thus far outlined the points highlighted in previous studies relating to proliferating HEMP attack capabilities. There is still the question of what sort of specific measures are demanded for preparing against these EMP threats. Previous studies state that as long as HEMP is caused by HANE, the most vital measure for protecting against HEMP is strengthening missile defense. Furthermore, to ensure appropriate responses are taken in the event of an actual EMP strike, the studies note the importance of establishing national plans against EMP threats, as well as enhancing multilateral coordination around responses to natural disasters such as solar storm.[56] Recent studies on HEMP threats show a trend towards discussing not deterrence against HEMP attacks themselves but the nature of consequence management, construing permanent blackouts caused by EMP as a new aspect of cyber-attack,[57] as well as a trend towards framing the situation as a broader emergency crisis management issue.[58]

James Jay Carafano, Richard Weitz, and others have looked deeper at the direct and secondary disasters brought about by large-scale blackouts, and have come up with a to-do list: prevent manifestation of the EMP threat; strengthen resilience; plan for unthinkable situations; and strengthen communication capacity.[59] Their studies contend that the damages sustained from Hurricane Katrina in the United States offer the best lessons learned for developing EMP threat scenarios.[60] In addition, to mitigate EMP effects, the studies underline the importance of developing a resilient U.S.-Canadian power grid, conducting integrated disaster response planning between the United States and Canada, and maintaining redundant global communications infrastructure. Along with these measures, the studies propose strengthening ballistic missile defense (BMD) against HEMP attacks and pursuing more aggressive counter-proliferation measures.[61] These are critical ideas for increasing survivability and restoration capacity in response to EMP effects caused by solar storms—an event largely beyond human control, and to terror attacks employing localized HPM.

As for recent Japanese studies discussing deterrence and consequence management against HEMP attacks, there are the policy proposals made by the CBRNE workshop of the Japan Forum for Strategic Studies (JFSS).[62] The report of the CBRNE workshop explains the importance of

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55 Yasuhito Fukushima, "Kenzaika suru Tai-uchū Shisutemu no Kyōi" [The Manifesting Threat of Anti-Space Systems], *Japan Association of Disarmament Studies (JADS) News Letter*, no.12, November 2, 2012, http://www.disarmament.jp/pdf/NL12.pdf, p.9.

56 Carafano and Weitz, "EMP Attacks-What the U.S. Must Do Now," pp.14-15; Maloof, *A Nation Forsaken – EMP: The Escalating Threat of an American Catastrophe*, pp.102-103.

57 George Loukas, *Cyber-Physical Attacks: A Growing Invisible Threat*, Oxford: Elsevier, 2015, pp.225-227.

58 James Woolsey and Peter V. Pry, "Op-Ed: EMP Blackout Could be Closer than You Think," *Arutz Sheva Israelnationalnews.com*, November 7, 2013; Peter Vincent Pry, "PRY: NatGeo Docudrama's Horror Very Real," *The Washington Times*, November 3, 2013.

59 Carafano and Weitz, "EMP Attacks-What the U.S. Must Do Now," p.12.

60 Ibid., p.8.

61 Ibid., p.2.

62 CBRNE Workshop, ed., *Seisaku Teigen Shiri-zu 2: Koukoudo Denji Parusu (HEMP) Kougeki ni yoru Infura Hakai no Kyoui eno Taisho [Policy Proposal Series No.2: Response to the Threat of Destruction of Infrastructures by HEMP Attack]*, Japan Forum for Strategic Studies, March 2016.

developing mutual support mechanisms between states, and of the usefulness and limits of BMD. The report also calls for making organizations such as the national government, ministries and agencies, local governments, and companies resilient and redundant should there be an EMP attack. Furthermore, there are the study findings of the Technical Committee on Electromagnetic Compatibility of the Institute of Electrical Engineers of Japan. They mainly outline measures from a technical perspective for preventing the penetration of electromagnetic waves into electrical equipment, taking also into account EMP.[63] According to this study, measures that protect against electromagnetic waves penetrating electrical equipment are the primary measures against EMP, whether they are caused by HPM, solar storm, or HEMP. Specifically, the study states that it is effective to prevent penetration from cables connected to electrical equipment, protect equipment by using electromagnetic shielding materials, confine damage by miniaturizing circuit boards and optimizing component placement and wiring patterns, and lastly, install fixtures that limit current or voltage as well as filters similar to lightning arresters in order to protect against instantaneous high voltage (high current) surges. In particular, the installation of fixtures that limit current or voltage as well as filters are viewed as necessary to protect against HEMP, whose electromagnetic field strength extending to the Earth's surface is said to reach approximately 50 kV/m at peak value.[64]

While a variety of approaches for mitigating the HEMP threat and EMP effects have been recently discussed in this manner, it is not hard to imagine the difficulty of making general prescriptions for addressing EMP threats, which must be based on cross-disciplinary considerations. If we nevertheless attempt to summarize the essence of the discussions, it is that EMP requires approaches that adopt the broadest possible scope, taking into consideration: the fundamental issue of how countries take measures to protect their critical electrical equipment and communications infrastructure from EMP; as well as scenario-based studies of deterrence and consequence management against HEMP attacks; ensuring society's survivability and ability to recover from more general blackout situations in terms of emergency crisis management; and examination of inter-state coordination.

(3) Discourse on deterrence building and consequence management for HEMP attacks

An interesting facet of the discussions on the HEMP threat is that EMP has rarely been featured in the discussions on post-Cold War security policy, especially nuclear deterrence policy. One of the reasons cited is that at the height of the U.S.-Soviet standoff underpinned by their vast nuclear capabilities, it was difficult to realistically conceive that the countries would utilize nuclear assets only for the purpose of producing HEMP, even if they understood the threat HEMP poses to communications and electrical infrastructure; such nuclear assets were intended for targeting an adversary's strategic positions.[65] In general, even if attention were directed to the physical damages produced by an explosion of a nuclear weapon, such as heat ray, blast, shock wave, initial radiation, and residual radiation, or to the operational strategy for using them as weapons,

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63 The Institute of Electrical Engineers of Japan, ed., *Denjiha to Jōhō Sekyuriti Taisaku Gijutsu*.

64 Ibid., pp.60-62, p.203.

65 Richard L. Garwin, "Opinion: EMP Can't Stop American Nuclear Retaliation," *The New York Times*, December 4, 1983, http://www.nytimes.com/1983/12/04/opinion/l-emp-can-t-stop-american-nuclear-retaliation-084377.html.

EMP was seen only as a secondary effect of a nuclear detonation.[66] Its effects themselves may not have been a major concern in the field of international security. In 2010, U.S. House deliberations on a bill to require the Director of National Intelligence to submit a report on the status of other countries' development of EMP weapons made reference to EMP weapons conceivably having effects similar to HEMP generated by a nuclear attack but not being included in the deterrence calculations normally applied to nuclear weapons.[67]

However, we can observe that during the Cold War, the EMP threat was raised as an issue as part of the strategy discussions. For example, Herman Kahn gives the following scenario for the outbreak of all-out nuclear war due to limited nuclear attack: the Soviet Union attempts a HEMP attack with the intention of destroying U.S. military communications infrastructure, and if this is successful, the Soviet Union would follow up with an ultimate attack; on the other hand, if the HEMP attack does not demonstrate the expected outcome, the Soviet Union could use it as an exemplary attack that does not harm the lives of U.S. citizens, not inviting U.S. military retaliation.[68] Also, Desmond Ball and Jeffrey Richelson, known for their studies on strategic nuclear attack targets, refer to HEMP attacks in their consideration of strategic nuclear attacks against nuclear power plants, and introduce various discussions on their effectiveness.[69]

In North America, a variety of concrete measures against the EMP threat as well as emergency crisis management approaches are now being attempted or debated. Since the 2000s, the U.S. Department of Defense has undertaken a number of studies which account for the EMP threat, some of which have been published as reports. An example is the 2005 report of the Defense Science Board (DSB) Task Force on "Nuclear Weapon Effects: Test, Evaluation, and Simulation."[70] Other examples include the "Unconventional Operational Concepts and the Homeland" report[71] released in 2009 and the "Survivability of Systems and Assets to Electromagnetic Pulse (EMP) and other Nuclear Weapon Effects (NWE)" report[72] published as an interim report of the DSB Task Force in 2011. Further, in 2010, a workshop entitled "In the Dark: Military Planning for a Catastrophic Critical Infrastructure Event" was held at the U.S. Army War College. Recognizing that solar storms and HEMP are the most likely occurring critical EMP events, the workshop examined how to prepare, respond, and recover from power loss events similar to cyber-attacks on the SCADA

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66 Hattori, *Kakuheiki no Hōkatsuteki Kenkyū*, pp.190-193.

67 U.S. House of Representatives, 111th Congress, 2nd Session, "H.R.6471, A Bill to Require the Director of National Intelligence to Submit a Report on the Foreign Development of Electromagnetic Pulse Weapons," introduced to the House, December 1, 2010, http://fas.org/irp/congress/2010_cr/hr6471.html.

68 Herman Kahn, *Thinking About the Unthinkable in the 1980s*, New York: Simon & Schuster, 1984, pp.139- 140.

69 Desmond Ball and Jeffrey Richelson, eds., *Strategic Nuclear Targeting*, Ithaca: Cornell University Press, 1986, pp.2254-2260.

70 *Report of the Defense Science Board Task Force on Nuclear Weapon Effects: Test, Evaluation, and Simulation,* Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, April 2005, http://www.fas.org/irp/agency/dod/dsb/nweffects.pdf.

71 *A Panel Report of the Defense Science Board 2007 Summer Study on Challenges to Military Operations in Support of U.S. Interests: Unconventional Operational Concepts and the Homeland*, Office of the Under Secretary of Defense For Acquisition, Technology, and Logistics, March 2009, http://www.acq.osd.mil/dsb/reports/ADA498404.pdf.

72 *Interim Report of the Defense Science Board (DSB) Task Force on the Survivability of Systems and Assets to Electromagnetic Pulse (EMP) and other Nuclear Weapon Effects (NWE)*, Office of the Under Secretary of Defense For Acquisition, Technology, and Logistics, August 2011, http://www.acq.osd.mil/dsb/reports/ADA550250.pdf.

systems mentioned earlier in this article.[73] In 2013, the U.S. Army War College also presented research outcomes entitled, "Terminal Blackout: Critical Electric Infrastructure Vulnerabilities and Civil-Military Resiliency."[74] As can be seen from these examples, ongoing studies are being conducted on the risks posed by HEMP, along with cyber-attack, solar storm, HPM, natural disaster, and other terror attacks, as well as on the nature of survivability and resiliency to these risks, by way of synthesizing them as threats to the power grid.

(4) The humanitarian issue of nuclear weapons and the EMP threat

Since the Cold War, one of the approaches for defending against the threat of nuclear weapons has been international efforts at nuclear disarmament and non-proliferation. As long as the HEMP threat originates from HANE—a type of a nuclear attack, it is not an overstatement to suggest from a mid- to long-term perspective that response to the HEMP threat must start from nuclear disarmament and non-proliferation.

The PTBT is one of the initial achievements of these nuclear disarmament and non-proliferation efforts. Within the limited confines of prohibiting atmospheric nuclear tests, the PTBT essentially has the effect of setting a norm banning HANE. In today's nuclear disarmament and non-proliferation frameworks, very few bilateral and multilateral treaties regulate HEMP attacks or restrict the operation of nuclear weapons, excluding some exceptions. This exception is the Strategic Arms Limitation Talks 2 (SALT-2) between the United States and the Soviet Union of 1972. During the Cold War, the Soviet Union developed and deployed a space-deployable nuclear asset resembling a satellite that was also capable of HEMP attacks called a Fractional Orbital Bombardment System (FOBS).[75] Despite this, it is understood that the United States and the Soviet Union ultimately agreed to prohibit the deployment of these weapons and signed SALT-2.[76]

As this article has examined, however, HEMP has been considered an event which occurs incidental to a nuclear explosion at high altitude. Therefore, a universal approach that directly regulates HEMP attacks was never adopted. For example, it is difficult to say that the Comprehensive Nuclear-Test-Ban Treaty (CTBT) or the Nuclear Non Proliferation Treaty (NPT) has the proper legal basis for condemning and stigmatizing states that attempt to carry out HEMP attacks. Nevertheless, permanent blackouts that could be caused by HEMP attacks is a serious and grave issue which should be framed as a humanitarian issue of nuclear weapons. It cannot be denied that a prolonged blackout over a large area could result in a catastrophic humanitarian impact similar to a direct nuclear attack.

In this connection, in recent years, the international community has begun to turn its attention to the perspective of the humanitarian aspects of nuclear weapons. This perspective embodies many noteworthy aspects also in the context of this article's discussion of the HEMP threat as humanitarian consequences. In this light, the background leading up to this development

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73 Kevin Cogan, "In the Dark: Military Planning for a Catastrophic Critical Infrastructure Event," *CSL Study*, May 2011, http://www.nuevatribuna.es/media/nuevatribuna/files/2014/02/06/inthedark.pdf.

74 Cynthia E. Ayers and Kenneth D. Chrosniak, "Terminal Blackout: Critical Electric Infrastructure Vulnerabilities and Civil-Military Resiliency," *CSLD Issue Paper*, vol.1-13, October 2013, http://www.csl.army.mil/usacsl/publications/IP_1-13-Critical_Electric_Infrastructure.pdf.

75 Woolsey and Pry, "The Growing Threat from an EMP Attack."

76 "R-36O / SL-X-? FOBS," Federation of American Scientists, http://fas.org/nuke/guide/russia/icbm/r-36o.htm.

is reviewed in detail below. First, a humanitarian approach to nuclear disarmament was adopted at the 2010 NPT Review Conference. In turn, at the first session of the Preparatory Committee in 2012 for the NPT Review Conference in 2015, a joint statement on the humanitarian impact of nuclear weapons was submitted by 16 countries. Subsequently, at the United Nations General Assembly session in 2012, a 34-state coalition submitted a similar proposal.[77] At an NPT Review Conference Preparatory Committee session in 2013, 74 countries endorsed the joint address on the humanitarian impact of nuclear weapons delivered by the South African delegate[78]; this cause has continued to gain rapid and widespread support.

Based on the coalition's growing recognition of the humanitarian impact of nuclear weapons, a new international effort was launched in a cross-disciplinary field of the NPT Review Conference relating to the new nature of nuclear disarmament and non-proliferation. At the Conference on the Humanitarian Impact of Nuclear Weapons (Oslo Conference) held in Oslo, Norway in March 2013, experts discussed the short- and long-term impacts of the use of nuclear weapons from a scientific standpoint. The conference was attended by over 500 people from 127 countries excluding 5 nuclear-weapon states, as well as the United Nations and various organizations.[79] This conference, which drew attention from the contexts of both nuclear disarmament and nuclear non-proliferation, was followed up by the second conference (Nayarit Conference) held in February 2014 in Nayarit, Mexico attended by 146 countries as well as the United Nations, other organizations, and NGOs.[80] In December 2014, the third conference (Vienna Conference) was held in Vienna, Austria, whose 158 participating countries included nuclear-weapon states for the first time—the United States and the United Kingdom.[81]

What discussions took place on the threat of HANE and HEMP at these conferences? The presentations from the first Oslo Conference are available on the Internet.[82] While there is evidence that discussions took place on the impact of a nuclear weapon detonation on the human body, simulation of destruction in cities, and preparedness for nuclear explosions, no references can be found for the HEMP threat. At the following Nayarit Conference, presenters principally discussed the socio-economic impacts of a nuclear weapon detonation, and there was only one

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77 Mitsuru Kurosawa, "2013 NPT Preparatory Committee and Nuclear Disarmament," *Journal of Osaka Jogakuin University*, vol.10, 2013, pp.85-87, http://www.wilmina.ac.jp/ojc/edu/kiyo_2013/kiyo_10_PDF/d2013_07.pdf.

78 Ministry of Foreign Affairs of Japan (MOFA), "2015 nen NPT Unyō Kentō Kaigi Dai 2 kai Junbi Iinkai (Gaiyō to Hyōka)" [Second Session of the Preparatory Committee for the 2015 NPT Review Conference (Overview and Evaluation)], May 3, 2013, http://www.mofa.go.jp/mofaj/gaiko/page3_000130.html.

79 MOFA, "Kakuheiki no Jindōteki Eikyō ni kansuru Kokusai Kaigi (Gaiyō to Hyōka)" [Conference on the Humanitarian Impact of Nuclear Weapons (Overview and Evaluation)], March 6, 2013, http://www.mofa.go.jp/mofaj/gaiko/kaku/hinw_201303.html.

80 MOFA, "Dai 2 kai Kakuheiki no Jindōteki Eikyō ni kansuru Kaigi (Gaiyō to Hyōka)" [Second Conference on the Humanitarian Impact of Nuclear Weapons (Overview and Evaluation)], February 17, 2014, http://www.mofa.go.jp/mofaj/dns/ac_d/page22_000925.html.

81 MOFA, "Dai 3 kai Kakuheiki no Jindōteki Eikyō ni kansuru Kaigi" [Third Conference on the Humanitarian Impact of Nuclear Weapons], December 25, 2014, http://www.mofa.go.jp/mofaj/dns/ac_d/page24_000380.html.

82 Government of Norway, *Presentations at the Human Impact of Nuclear Weapons*, March 2013, http://www.regjeringen.no/en/topics/foreign-affairs/humanitarian-efforts/presentations_humimpact/id715937/.

presentation that touched upon the 2008 report of the EMP Commission.[83] No discussion of the EMP threat is found in the other presentations from the conference; neither is EMP mentioned in the Chair's Summary.[84] The presentations from the Vienna Conference[85] included a presentation[86] that referred to the incidental occurrence of EMP as an anticipated scenario of a nuclear weapon detonation at a military base in Europe. However, again, discussion of the HEMP threat is not found in the other presentations from the conference, and the threat is not mentioned in the Chair's Summary.[87] What's more, the humanitarian impact of HANE and HEMP is not found at all in the discussions at either the Main Committee I (nuclear disarmament) or Main Committee II (nuclear non-proliferation) at the NPT Review Conference held in New York in May 2015.[88]

Because there are no specific cases from the past that we can refer to for understanding the damages a HEMP attack could inflict on today's highly advanced information society, we cannot discuss the true threat of EMP other than by making projections based on data from atmospheric nuclear tests conducted during the Cold War, or by deducing from the damages caused by solar storms or findings from simulations using small EMP testing systems. As was examined up to the previous section, however, it is clear that with the passage of time, a permanent blackout that could cover a large area due to cascading effects will have serious impacts on the country subjected to a HEMP attack, particularly its civil society. As long as HEMP is generated from HANE, the latter constitutes a type of nuclear attack in the sense that a nuclear asset is being utilized for a particular operation. If this is so, this is an urgent issue that should be discussed squarely, also within the scope of the humanitarian aspects of nuclear weapons.

In other words, it is most relevant today that the humanitarian impact of nuclear weapons is explored in discussing the EMP threat under the existing international frameworks related to nuclear disarmament and non-proliferation. That nonetheless the EMP threat was hardly considered in the discussions from the Oslo Conference through the Vienna Conference is disquieting.

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83 Richard Moyes, "Impact of a nuclear weapon detonation on infrastructure and the economy," paper presented at the Second Conference on the Humanitarian Impact of Nuclear Weapons, Nayarit, Mexico, February 13-14, 2014, http://www.sre.gob.mx/en/images/stories/cih/article36.pdf.

84 "Chair's Summary," Second Conference on the Humanitarian Impact of Nuclear Weapons, Nayarit, Mexico, February 14, 2014, http://www.sre.gob.mx/en/images/stories/cih/ci.pdf.

85 Europe Integration Foreign Affairs, Federal Ministry Republic of Austria, "HINW14vienna - Presentations," December 8-9, 2014, http://www.bmeia.gv.at/en/european-foreign-policy/disarmament/weapons-of-mass-destruction/nuclear-weapons-and-nuclear-terrorism/vienna-conference-on-the-humanitarian-impact-of-nuclear-weapons/presentations/.

86 Matthew McKinzie et al., "Calculating the Effects of a Nuclear Explosion at a European Military Base," paper presented at the Vienna Conference on the Humanitarian Impact of Nuclear Weapons, December 8-9, 2014, http://www.bmeia.gv.at/fileadmin/user_upload/Zentrale/Aussenpolitik/Abruestung/HINW14/Presentations/HINW14_S1_Presentation_NRDC_ZAMG.pdf.

87 "Report and Summary of Findings of the Conference," Vienna Conference on the Humanitarian Impact of Nuclear Weapons, December 8-9, 2014, http://www.bmeia.gv.at/fileadmin/user_upload/Zentrale/Aussenpolitik/Abruestung/HINW14/HINW14_Chair_s_Summary.pdf.

88 "Draft Final Document Volume 1," 2015 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, May 21, 2015, http://www.reachingcriticalwill.org/images/documents/Disarmament-fora/npt/revcon2015/documents/DraftFinalDocument.pdf.

Conclusion

This article focused on HEMP and attempted to examine its different aspects. Once again it has shed light on the vulnerability of the electrical and communication infrastructure supporting today's society to EMP, as well as the extent of confusion that would be created should there be a HEMP attack and the cost required to restore the power grid. The EMP threat is an old and yet a new issue. Of these issues, HEMP resulting from HANE is a vital issue that has been absent from past efforts aimed at the disarmament and non-proliferation of nuclear weapons. In this light, in order to mitigate the present risk of a HEMP attack between two nations, it is a matter of top priority that all nuclear-weapon and non-nuclear-weapon states first reach a shared understanding that HANE is none other than a nuclear attack. To do this, it may be wise to build upon the multilateral treaties related to nuclear test bans as a platform for discussion. For example, an idea is to utilize opportunities such as the Conference on Facilitating the Entry into Force of the CTBT to bring the international community's attention to the threat, both from the standpoints of the technical aspects of HANE and HEMP and the humanitarian viewpoint of EMP effects.

A HEMP attack is indisputably a type of nuclear attack, and can be considered an asymmetrical threat that results in terminal damages to electrical and communication infrastructure, without instantly causing loss of human life. Moreover, as this article has examined, the impact of a HEMP attack will highly likely be widespread and long-term. Furthermore, there is concern that the attack would be accompanied with catastrophic damages beyond imagination with the passage of time. Although this article did not review projections of casualties and injuries following a HEMP attack, many of the analyses in previous studies agree that there would be considerable loss of human life as a result of serious interruptions to the supply of food, water, and fuel, as well as security issues and disruptions in health, medical, communication, and other services, as suggested by the description, "the route back to the 19th century." In short, these are none other than humanitarian issues caused by nuclear weapons.

Needless to say, it is essential that countries take responses such as strengthening the survivability of their societies and infrastructure to EMP, enhancing missile defense based on HANE scenarios, and coordinating multilaterally during large-scale permanent blackouts caused by a HEMP attack. At the same time, from a mid- to long-term perspective, it may be important to defend against the EMP threat by re-raising the issues of HANE separately as part of the discussion on the humanitarian issue of nuclear weapons, and aiming to establish international norms prohibiting HEMP attacks.