STATEMENT FOR THE RECORD
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COMMISSION TO ASSESS THE THREAT TO THE UNITED STATES FROM ELECTROMAGNETIC PULSE (EMP) ATTACK
TO
U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON HOMELAND SECURITY
SUBCOMMITTEE ON OVERSIGHT AND MANAGEMENT EFFICIENCY
HEARING
"EMPTY THREAT OR SERIOUS DANGER:
ASSESSING NORTH KOREA'S RISK TO THE HOMELAND"
October 12, 2017

North Korea Nuclear EMP Attack: An Existential Threat

During the Cold War, major efforts were undertaken by the Department of Defense to assure that the U.S. national command authority and U.S. strategic forces could survive and operate after an EMP attack. However, no major efforts were then thought necessary to protect critical national infrastructures, relying on nuclear deterrence to protect them. With the development of small nuclear arsenals and long-range missiles by new, radical U.S. adversaries, beginning with North Korea, the threat of a nuclear EMP attack against the U.S. becomes one of the few ways that such a country could inflict devastating damage to the United States. It is critical, therefore, that the U.S. national leadership address the EMP threat as a critical and existential issue, and give a high priority to assuring the leadership is engaged and the necessary steps are taken to protect the country from EMP.

By way of background, the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack was established by Congress in 2001 to advise the Congress, the President, Department of Defense and other departments and agencies of the U.S. Government on the nuclear EMP threat to military systems and civilian critical infrastructures. The EMP Commission was re-established in 2015 with its charter broadened to include natural EMP from solar storms, all manmade EMP threats, cyber-attack, sabotage and Combined-Arms Cyber Warfare. The EMP Commission charter gives it access to all relevant classified and unclassified data and the power to levy analysis upon the Department of Defense.

On September 30, 2017, the Department of Defense, after withholding a significant part of the monies allocated by Congress to support the work of the EMP Commission for the entirety of 2016, terminated funding the EMP Commission. In the same month, North Korea detonated an H-Bomb that it plausibly describes as capable of "super-powerful EMP" attack and released a technical report "The EMP Might of Nuclear Weapons" accurately describing what Russia and China call a "Super-EMP" weapon.

Neither the Department of Defense nor the Department of Homeland Security has asked Congress to continue the EMP Commission. The House version of the National Defense Authorization Act includes a provision that would replace the existing EMP Commission with new Commissioners. Yet the existing EMP Commission comprises the nation's foremost experts who have been officially or unofficially continuously engaged trying to advance national EMP preparedness for 17 years.

And today, as the EMP Commission has long warned, the nation faces a potentially imminent and existential threat of nuclear EMP attack from North Korea. Recent events have proven the EMP Commission's critics wrong about other highly important aspects of the nuclear missile threat from North Korea:

--Just six months ago, most experts thought North Korea's nuclear arsenal was primitive, some academics claiming it had as few as 6 A-Bombs. Now the intelligence community reportedly estimates North Korea has 60 nuclear weapons.
--Just six months ago, most experts thought North Korea's ICBMs were fake, or if real could not strike the U.S. mainland. Now the intelligence community reportedly estimates North Korea's ICBMs can strike Denver and Chicago, and perhaps the entire United States.
--Just six months ago, most experts thought North Korea was many years away from an H-Bomb. Now it appears North Korea has H-Bombs comparable to sophisticated U.S. two-stage thermonuclear weapons.
--Just six months ago, most experts claimed North Korean ICBMs could not miniaturize an A-Bomb or design a reentry vehicle for missile delivery. Now the intelligence community reportedly assesses North Korea has miniaturized nuclear weapons, and has developed reentry vehicles for missile delivery, including by ICBMs that can strike the U.S.[1]

After massive intelligence failures grossly underestimating North Korea's long-range missile capabilities, number of nuclear weapons, warhead miniaturization, and proximity to an H-Bomb, the biggest North Korean threat to the U.S. remains unacknowledged—nuclear EMP attack.

North Korea confirmed the EMP Commission's assessment by testing an H-Bomb that could make a devastating EMP attack, and in its official public statement: "The H-Bomb, the explosive power of which is adjustable from tens of kilotons to hundreds of kilotons, is a multi-functional thermonuclear weapon with great destructive power which can be detonated even at high altitudes for super-powerful EMP attack according to strategic goals."[2]

[1] Joby Warwick, Ellen Nakashima, Anna Fifield, "North Korea Is No Making Missile-Ready Nuclear Weapons, U.S. Analysts Say" Washington Post, August 18, 2017; Michelle Ye Hee Lee, "North Korean Nuclear Test May Have Been Twice As Strong As First Thought" Washington Post, September 13, 2017; Jack Kim, Soyoung Kim, "North Korea Says It Has Developed A More Advanced Hydrogen Bomb That Can Be Loaded Onto An ICBM" Business Insider, September 2, 2017; NBC News, "'A Big Hoax': Experts Say North Korea Showing Off Missiles That Can't Fly" August 15, 2013.
[2] Bill Gertz, "Korea Nuclear Test Furthers EMP Bomb" Washington Free Beacon, September 6, 2017.

As noted earlier, Pyongyang also released a technical report accurately describing a "Super-EMP" weapon.[3]

Just six months ago, some academics dismissed EMP Commission warnings and even, literally, laughed on National Public Radio at the idea North Korea could make an EMP attack.

Primitive and "Super-EMP" Nuclear Weapons are Both EMP Threats

The EMP Commission finds that even primitive, low-yield nuclear weapons are such a significant EMP threat that rogue states, like North Korea, or terrorists may well prefer using a nuclear weapon for EMP attack, instead of destroying a city: "Therefore, terrorists or state actors that possess relatively unsophisticated missiles armed with nuclear weapons may well calculate that, instead of destroying a city or military base, they may obtain the greatest political-military utility from one or a few such weapons by using them—or threatening their use—in an EMP attack."[4]

The EMP Commission 2004 Report warns: "Certain types of relatively low-yield nuclear weapons can be employed to generate potentially catastrophic EMP effects over wide geographic areas, and designs for variants of such weapons may have been illicitly trafficked for a quarter-century."[5]

In 2004, two Russian generals, both EMP experts, warned the EMP Commission that the design for Russia's Super-EMP warhead, capable of generating high intensity EMP fields over 100,000 volts per meter, was "accidentally" transferred to North Korea. They also said that due to "brain drain," Russian scientists were in North Korea, as were Chinese and Pakistani scientists according to the Russians, helping with the North's missile and nuclear weapon programs. In 2009, South Korean military intelligence told their press that Russian scientists are in North Korea helping develop an EMP nuclear weapon. In 2013, a Chinese military commentator stated North Korea has Super-EMP nuclear weapons.[6]

Super-EMP weapons are low-yield and designed to produce not a big kinetic explosion, but rather a high level of gamma rays, which generates the high-frequency E1 EMP that is most damaging to the broadest range of electronics. North Korean nuclear tests, including the first in 2006, whose occurrence was predicted to the EMP Commission two years in advance by the two

[3] Ibid. Kim Song-won, Dean of Kim Chaek University of Technology "The EMP Might of Nuclear Weapons" Rodong Sinmun, Pyongyang, September 4, 2017.

[4] Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack, *Executive Report*, 2004, p. 2.

[5] Ibid.

[6] U.S. Senate, Hearing, Statement for the Record, Dr. Peter Vincent Pry, "Foreign Views of Electromagnetic Pulse (EMP) Attack" testimony on behalf of EMP Commission before the Subcommittee on Terrorism, Technology, and Homeland Security, Senate Committee on the Judiciary (Washington, D.C.: March 9, 2005); Kim Min-sek and Yoo Jee-ho, "Military Source Warns of North's EMP Bomb" JoonAng Daily (September 2, 2009); Li Daguang, "North Korean Electromagnetic Attack Threatens South Korea's Information Warfare Capabilities" Tzu Chin, No. 260 (June 1, 2012) pp. 44-45.

Russian EMP experts, mostly have yields consistent with the size of a Super-EMP weapon. The Russian generals' accurate prediction about when North Korea would perform its first nuclear test, and of a yield consistent with a Super-EMP weapon, indicates their warning about a North Korean Super-EMP weapon should be taken very seriously.

EMP Threat From Satellites

While most analysts are fixated on when in the future North Korea will develop highly reliable intercontinental missiles, guidance systems, and reentry vehicles capable of striking a U.S. city, the threat here and now from EMP is largely ignored. EMP attack does not require an accurate guidance system because the area of effect, having a radius of hundreds or thousands of kilometers, is so large. No reentry vehicle is needed because the warhead is detonated at high-altitude, above the atmosphere. Missile reliability matters little because only one missile has to work to make an EMP attack against an entire nation.

North Korea could make an EMP attack against the United States by launching a short-range missile off a freighter or submarine or by lofting a warhead to 30 kilometers burst height by balloon. While such lower-altitude EMP attacks would not cover the whole U.S. mainland, as would an attack at higher-altitude (300 kilometers), even a balloon-lofted warhead detonated at 30 kilometers altitude could blackout the Eastern Electric Power Grid that supports most of the population and generates 75 percent of U.S. electricity.

Or an EMP attack might be made by a North Korean satellite, right now.

A Super-EMP weapon could be relatively small and lightweight, and could fit inside North Korea's Kwangmyongsong-3 (KMS-3) and Kwangmyongsong-4 (KMS-4) satellites. These two satellites presently orbit over the United States, and over every other nation on Earth--demonstrating, or posing, a potential EMP threat against the entire world.

North Korea's KMS-3 and KMS-4 satellites were launched to the south on polar trajectories and passed over the United States on their first orbit. Pyongyang launched KMS-4 on February 7, 2017, shortly after its fourth illegal nuclear test on January 6, that began the present protracted nuclear crisis with North Korea.

The south polar trajectory of KMS-3 and KMS-4 evades U.S. Ballistic Missile Early Warning Radars and National Missile Defenses, resembling a Russian secret weapon developed during the Cold War, called the Fractional Orbital Bombardment System (FOBS) that would have used a nuclear-armed satellite to make a surprise EMP attack on the United States.[7]

Ambassador Henry Cooper, former Director of the U.S. Strategic Defense Initiative, and a preeminent expert on missile defenses and space weapons, has written numerous articles warning

[7] Miroslav Gyurosi, *The Soviet Fractional Orbital Bombardment System Program*, (January 2010) Technical Report APA-TR-2010-010.

about the potential North Korean EMP threat from their satellites. For example, on September 20, 2016 Ambassador Cooper wrote:

U.S. ballistic missile defense (BMD) interceptors are designed to intercept a few North Korean ICBMs that approach the United States over the North Polar region. But current U.S. BMD systems are not arranged to defend against even a single ICBM that approaches the United States from over the South Polar region, which is the direction toward which North Korea launches its satellites…This is not a new idea. The Soviets pioneered and tested just such a specific capability decades ago—we call it a Fractional Orbital Bombardment System (FOBS)…So, North Korea doesn't need an ICBM to create this existential threat. It could use its demonstrated satellite launcher to carry a nuclear weapon over the South Polar region and detonate it…over the United States to create a high-altitude electromagnetic pulse (HEMP)…The result could be to shut down the U.S. electric power grid for an indefinite period, leading to the death within a year of up to 90 percent of all Americans—as the EMP Commission testified over eight years ago.[8]

Former NASA rocket scientist James Oberg visited North Korea's Sohae space launch base, witnessed elaborate measures undertaken to conceal space launch payloads, and concludes in a 2017 article that the EMP threat from North Korea's satellites should be taken seriously:

…there have been fears expressed that North Korea might use a satellite to carry a small nuclear warhead into orbit and then detonate it over the United States for an EMP strike. These concerns seem extreme and require an astronomical scale of irrationality on the part of the regime. The most frightening aspect, I've come to realize, is that exactly such a scale of insanity is now evident in the rest of their 'space program." That doomsday scenario, it now seems, has been plausible enough to compel the United States to take active measures to insure that no North Korean satellite, unless thoroughly inspected before launch, be allowed to reach orbit and ever overfly the United States.[9]

Kim Jong-Un has threatened to reduce the United States to "ashes" with "nuclear thunderbolts" and threatened to retaliate for U.S. diplomatic and military pressure by "ordering officials and scientists to complete preparations for a satellite launch as soon as possible" amid "the enemies'

[8] Ambassador Henry F. Cooper, "Whistling Past The Graveyard…" High Frontier (September 20, 2016) highfrontier.org/sept-20-2016-whistling-past-the-graveyard/ See also: highfrontier.org/category/fobs. On up to 90% U.S. fatalities from an EMP attack, during a congressional hearing, Rep. Roscoe Bartlett asked me if such high fatalities could result, and I responded: "We don't have experience with losing the infrastructure in a country with 300 million people, most of whom don't live in a way that provides for their own food and other needs. We can go back to an era when people did live like that. That would be—10 percent would be 30 million people, and that is probably the range where we could survive as a basically rural economy." U.S. House of Representatives, Hearing, "Threat Posed By Electromagnetic Pulse (EMP) Attack" Committee on Armed Services (Washington, D.C.: July 10, 2008), p. 9.

[9] Jim Oberg, Space Review (February 6, 2017) www.thespacereview.com/article/3164/1in a 2017 aricle

harsh sanctions and moves to stifle" the North.[10] North Korean press (for example in Rodong Sinmun; March 7, 2016) asserts readiness for "any form of war" and includes their satellite with "strengthening of the nuclear deterrent and legitimate artificial satellite launch, which are our fair and square self-defensive choice." Moreover: "The nuclear [weapons] we possess are, precisely, the country's sovereignty, right to live, and dignity. Our satellite that cleaves through space is the proud sign that unfolds the future of the most powerful state in the world." The same article, like many others, warns North Korea makes "constant preparations so that we can fire the nuclear warheads, which have been deployed for actual warfare for the sake of national defense, at any moment!"

An earlier generation immediately understood the alarming strategic significance of Sputnik in 1957, yet few today understand or even care about the strategic significance of North Korea's satellites, perhaps because of widespread ignorance about EMP.

Addressing Misinformation

Misinformation about EMP abounds in the media, and even in many allegedly serious studies, from uninformed persons posturing as experts, who have no competency in EMP. False claims are often made that the EMP threat is "not real" but merely theoretical and greatly overblown.[11]

For example, one academic often quoted by the press claims that during the 1962 STARFISH PRIME high-altitude nuclear test, "just one string of street lights failed in Honolulu" and that this proved EMP is no threat.[12] In fact, the EMP knocked-out 36 strings of street lights, caused a telecommunications microwave relay station to fail, burned out HF (High-Frequency) radio links (used for long-distance communications), set off burglar alarms, and caused other damage.[13]

The Hawaiian Islands did not experience a catastrophic protracted blackout because they were on the far edge of the EMP field contour, where effects are weakest; are surrounded by an ocean, which mitigates EMP effects; and were still in an age dominated by vacuum tube electronics.

STARFISH PRIME was not the only test of this kind. Russia in 1961-62 also conducted a series of high-altitude nuclear bursts to test EMP effects over Kazakhstan, an industrialized area nearly

[10] Alex Lockie, "North Korea Threatens 'Nuclear Thunderbolts' As U.S. And China Finally Work Together" American Military News (April 14, 2017); Fox News, "U.S. General: North Korea 'Will' Develop Nuclear Capabilities To Hit America" (September 20, 2016) www.foxnews.com/world/2016/09/20/north-korea-says-successfully-ground-tests-new-rocket-engine.html

[11] See for example: Jeffrey Lewis, "Would A North Korean Space Nuke Really Lay Waste to the U.S.?" New Scientist www.newscientist.com/article/2129618; Lewis quoted in Cheyenne MacDonald, "A North Korean 'Space Nuke' Wouldn't Lay Waste To America" Daily Mail, May 3, 2017; Lewis interviewed by National Public Radio, "The North Korean Electromagnetic Pulse Threat, Or Lack Thereof" www.npr.org/2017/04/27/525833275; www.naturalnews.com/2017-05-01-npr-laughs-hysterically-north-korean-emp-nuclear-attack.html

[12] Ibid.

[13] Dr. William R. Graham, "North Korean Nuclear EMP Attack: An Existential Threat" 38 North, June 2, 2017.

as large as Western Europe.[14] That test destroyed the Kazakh electric grid.[15] Moreover, modern electronics, in part because they are designed to operate at much lower voltages, are much more vulnerable to EMP than the electronics of 1962 exposed to STARFISH PRIME and the Kazakh nuclear tests. A similar EMP event over the U.S. today would be an existential threat.[16]

Another academic wrongly asserts that because EMP from atmospheric nuclear tests in Nevada did not blackout Las Vegas, therefore EMP is no threat. The nuclear tests he describes were all endo-atmospheric tests that do not generate appreciable EMP fields beyond a range of about 5 miles. The high-altitude EMP (HEMP) threat of interest requires exo-atmospheric detonation, at 30 kilometers altitude or above, and produces EMP out to ranges of hundreds to thousands of miles. Las Vegas was not affected by the Nevada tests because they were endo-atmospheric nuclear tests that generated no HEMP.[17]

The same academic also miscalculates that "a 20-kiloton bomb detonated at optimum height would have a maximum EMP damage distance of 20 kilometers" in part, because he assumes "15,000 volts/meter or higher" in the E1 EMP component is necessary for damage. This figure is an extreme overestimate of system damage field thresholds. Damage and upset to electronic systems will happen from E1 EMP field strengths far below the academic's "15,000 volts/meter or higher." A one meter wire connected to a semiconductor device, such as a mouse cord or interconnection cable, would place hundreds to thousands of volts on microelectronic devices out to ranges of hundreds of miles for low-yield nuclear devices. Based on omission and other experience with many EMP tests, semiconductor junctions, operating at a few volts, will experience breakdown at a few volts over their operating point, allowing their power supply to destroy the junctions experiencing breakdown.[18]

The same academic and many other non-experts also ignore system upset as a vulnerability. Digital electronics can be upset by extraneous pulses of a few volts. For unmanned control systems present within the electric power grids, long-haul communication repeater stations, and gas pipelines, an electronic upset is tantamount to permanent damage. Temporary upset of electronics can also have catastrophic consequences for military operations. No electronics should be considered invulnerable to EMP unless hardened and tested to certify survivability.

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[14] High-altitude EMP (HEMP), the phenomenon under discussion, results from the detonation of a nuclear weapon at high-altitude, 30 kilometers or higher. All nuclear weapons, even a primitive Hiroshima-type A-bomb, can produce levels of HEMP damaging to modern electronics over large geographic regions.

[15] According to Electric Infrastructure Security Council, *Report: USSR Nuclear EMP Upper Atmosphere Kazakhstan Test 184*, (www.eiscouncil.org/APP_Data/upload/a4ce4b06-1a77-44d-83eb-842bb2a56fc6.pdf), citing research by Oak Ridge National Laboratory, a comparable EMP event over the U.S. today "would likely damage about 365 large transformers in the U.S. power grid, leaving about 40 percent of the U.S. population without electrical power for 4 to 10 years."

[16] EMP Commission *Executive Report*, op. cit., pp. 4-8.

[17] Jack Liu, "A North Korean EMP Attack?...Unlikely" 38 North, May 5, 2017.

[18] Ibid.

Some highly critical unprotected electronics have been upset or damaged in simulated EMP tests, not at "15,000 volts/meter or higher," but at threat levels far below 1,000 volts/meter.[19]

The North Korean missile test on April 29, 2017, which apparently detonated at an altitude of 72 kilometers, the optimum height-of-burst for EMP attack by a 10 KT warhead, would create a potentially damaging EMP field spanning, not the academic's miscalculated 20 kilometers radius, but to about 930 kilometers radius [Kilometers Radius = 110 (Kilometers Burst Height to the 0.5 Power)].[20]

Therefore, even for a low-yield 10-20 kiloton weapon, the EMP field should be considered dangerous for unprotected U.S. systems. The EMP Commission 2004 Report warned against the U.S. military's increasing use of commercial-off-the-shelf-technology that is not protected against EMP: "Our increasing dependence on advanced electronics systems results in the potential for an increased EMP vulnerability of our technologically advanced forces, and if unaddressed makes EMP employment by an adversary an attractive asymmetric option."[21]

Empirical Basis for EMP Threat Better Established than Cyber Threat

The empirical basis for the threat of an EMP attack to electric grids and other critical infrastructures is far deeper and broader than the data for cyber-attacks or sabotage. The notion that a cyber-attack or sabotage can plunge the U.S. into a protracted blackout--while very real threats that warrant deep concern--are far more theoretical constructs than EMP attack.

We know for certain that EMP will cause widespread damage of electronics and protracted blackout of unprotected electric grids and other critical infrastructures from such hard data as:

--The U.S. STARFISH PRIME high-altitude nuclear test in 1962 over Johnston Island that generated an EMP field over the Hawaiian Islands, over 1,300 kilometers away, causing widespread damage to electronic systems.[22]
--Six Russian EMP tests 1961-1962 over Kazakhstan that with a single weapon destroyed electric grids over an area larger than Western Europe, proving this capability six times.[23]
--30 years (1962-1992) of U.S. underground nuclear testing that included collecting data on EMP effects.
--Over 50 years of testing by EMP simulators, still ongoing, including by the Congressional EMP Commission (2001-2008) that proved modern electronics are over 1 million times more vulnerable to EMP than the electronics of 1962.[24]

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[19] Ibid.
[20] Ibid.
[21] EMP Commission, *Executive Report*, op. cit., p. 47.
[22] Phil Plait, "The 50th Anniversary of Starfish Prime: The Nuke That Shook The World" Discover, July 9, 2012.
[23] Jerry Emanuelson, "Soviet Test 184: The 1962 Soviet Nuclear EMP Tests Over Kazakhstan" Future Science, Undated; Vladimir M. Loborev, "Up to Date State of the NEMP Problems and Topical Research Directions" Electromagnetic Environments and Consequences: Proceedings of the European International Symposium on Electromagnetic Environments, EUROEM Conference, Bordeaux, France, 1994; V. N. Mikhailov, *The Nuclear Tests of the USSR*, Vol. 2, Institute of Strategic Stability, Rosatom.

Moreover, hard data proving the threat from nuclear EMP is available from natural EMP generated by geomagnetic storms, accidental damage caused by electromagnetic transients, and non-nuclear radiofrequency weapons (RF weapons). All of these produce field strengths much less powerful than nuclear EMP, and in the case of accidental electromagnetic transients and radiofrequency weapons, much more localized. There are many thousands of such cases.

Many documented examples of successful attacks using RF weapons, and accidents involving electromagnetic transients, are described in the Department of Defense *Pocket Guide for Security Procedures and Protocols for Mitigating Radio Frequency Threats* (Technical Support Working Group, Directed Energy Technical Office, Dahlgren Naval Surface Warfare Center). A few examples:

--"Radio Frequency Weapons were used in separate incidents against the U.S. Embassy in Moscow to falsely set off alarms and to induce a fire in a sensitive area."
--"In Kzlyar, Dagestan, Russia, Chechen rebel commander Salman Raduyev disabled police radio communications using RF transmitters during a raid."
--"In June 1999 in Bellingham, Washington, RF energy from a radar induced a SCADA malfunction that caused a gas pipeline to rupture and explode."
--"In 1999, a Robinson R-44 news helicopter nearly crashed when it flew by a high-frequency broadcast antenna."
--North Korea used a Radio Frequency Weapon, purchased from Russia, to attack airliners and impose an "electromagnetic blockade" on air traffic to Seoul, South Korea's capital. The repeated attacks by RFW also disrupted communications and the operation of automobiles in several South Korean cities in December 2010; March 9, 2011; and April-May 2012.[25]

Vulnerabilities to EMP

When assessing the potential vulnerability of U.S. military forces and civilian critical infrastructures to EMP, it is necessary to be mindful of the complex interdependencies of these highly-networked systems, because EMP upset and damage of a very small fraction of the total system can cause total system failure.[26]

Real world failures of electric grids from various causes indicate that a nuclear EMP attack would have catastrophic consequences. Significant and highly disruptive blackouts have been caused by single-point failures cascading into system-wide failures, originating from damage comprising far less than 1 percent of the total system. For example:

--The Great Northeast Blackout of 2003--that put 50 million people in the dark for a day, contributed to at least 11 deaths, and cost an estimated $6 billion—originated from a single

[24] "Electromagnetic Pulse: Threat to Critical Infrastructures" Hearing before the Subcommittee on Cybersecurity, Infrastructure Protection, and Security Technologies, House Committee on Homeland Security, Washington, D.C.: May 8, 2014.
[25] "Massive GPS Jamming Attack By North Korea" GPSWORLD.COM, May 8, 2012.
[26] Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack, *Critical National Infrastructures*, 2008, passim.

failure point when a powerline contacted a tree branch, damaging less than 0.0000001 (0.00001%) of the system.
--The New York City Blackout of 1977, that resulted in the arrest of 4,500 looters and injury of 550 police officers, was caused by a lightning strike on a substation that tripped two circuit breakers.
--The Great Northeast Blackout of 1965, that effected 30 million people, happened because a protective relay on a transmission line was improperly set.
--India's nationwide blackout of July 30-31, 2012—the largest blackout in history, effecting 670 million people, 9% of the world population—was caused by overload of a single high-voltage powerline.
--India's blackout of January 2, 2001—effecting 226 million people—was caused by equipment failure at the Uttar Pradesh substation.
--Indonesia's blackout of August 18, 2005—effecting 100 million people—was caused by overload of a high-voltage powerline.
--Brazil's blackout of March 11, 1999—effecting 97 million people—was caused by a lightning strike on an EHV transformer substation.
--Italy's blackout of September 28, 2003—effecting 55 million people—was caused by overload of two high-voltage powerlines.
--Germany, France, Italy, and Spain experienced partial blackouts on November 4, 2006—effecting 10-15 million people—from accidental shutdown of a high-voltage powerline.
--The San Francisco blackout in April 2017 was caused by the failure of a single high voltage breaker.

In contrast to the above blackouts caused by single-point or small-scale failures, a nuclear EMP attack would inflict massive widespread damage to the electric grid causing millions of failure points. With few exceptions, the U.S. national electric grid is unhardened and untested against nuclear EMP attack.

In the event of a nuclear EMP attack on the United States, a widespread protracted blackout is inevitable. This commonsense assessment is also supported by the nation's best computer modeling:

--Modeling by the U.S. Federal Energy Regulatory Commission (FERC) reportedly assesses that a terrorist attack that destroys just 9 of 2,000 EHV transformers--merely 0.0045 (0.45%) of all EHV transformers in the U.S. national electric grid--would be catastrophic damage, causing a protracted nationwide blackout.
--Modeling by the Congressional EMP Commission assesses that a terrorist nuclear EMP attack, using a primitive 10-kiloton nuclear weapon, could destroy dozens of EHV transformers, thousands of SCADAS and electronic systems, causing catastrophic collapse and protracted blackout of the U.S. Eastern Grid, putting at risk the lives of millions.[27]

[27]For the best unclassified modeling assessment of likely damage to the U.S. national electric grid from nuclear EMP attack see: U.S. Federal Energy Regulatory Commission (FERC) Interagency Report, coordinated with the Department of Defense and Oak Ridge National Laboratory: *Electromagnetic Pulse: Effects on the U.S. Power Grid,*

Thus, even if North Korea has only primitive, low-yield nuclear weapons, and likewise if other states or terrorists acquire one or a few such weapons, and the capability to detonate them at 30 kilometers or higher-altitude over the United States, as the EMP Commission warned over a decade ago in its 2004 Report: "The damage level could be sufficient to be catastrophic to the Nation, and our current vulnerability invites attack."[28]

What Is To Be Done?

We recommend establishing an Executive Agent – a Cabinet Secretary designated by the President – with the authority, accountability, and resources, to manage U.S. national infrastructure protection and defense against EMP and the other existential threats described above. Current institutional authorities and responsibilities–government, industry, regulatory agencies—are fragmented, incomplete, and unable to protect and defend against foreign hostile EMP threats or solar super-storms.

We encourage the President to work with Congressional leaders to stand-up an *ad hoc* Joint Presidential-Congressional Commission, with its members charged with supporting the Nation's leadership and providing expertise, experience, and oversight to achieve, on an accelerated basis, the protection of critical national infrastructures. The U.S. Federal Energy Regulatory Commission (FERC) and North American Electric Reliability Corporation (NERC) have for nearly a decade been unable or unwilling to implement the EMP Commission's recommendations. A Presidential-Congressional Commission on Critical Infrastructure Protection could engage the Free World's preeminent experts on EMP and Combined-Arms Cyber Warfare to serve the entire Government in a manner akin to the Atomic Energy Commission of the 1947-74 period, advising the Administration's actions to attain most quickly and most cost-effectively the protection essential to long-term national survival and wellbeing. The United States should not remain in our current state of fatal vulnerability to well-known natural and man-made threats.

We highly commend President Trump's new Executive Order "Strengthening the Cybersecurity of Federal Networks and Critical Infrastructure" signed on May 11, 2017. We strongly recommend that implementation of cybersecurity for the electric grid and other critical infrastructures include EMP protection, since all-out cyber warfare as planned by Russia, China, North Korea, and Iran includes nuclear EMP attack. However, current institutional arrangements for protecting and improving the reliability of the electric grids and other critical infrastructures through the U.S. FERC and the NERC are not designed to

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Executive Summary (2010); FERC Interagency Report by Edward Savage, James Gilbert and William Radasky, *The Early-Time (E1) High-Altitude Electromagnetic Pulse (HEMP) and Its Impact on the U.S. Power Grid* (Meta-R-320) Metatech Corporation (January 2010); FERC Interagency Report by James Gilbert, John Kappenman, William Radasky, and Edward Savage, *The Late-Time (E3) High-Altitude Electromagnetic Pulse (HEMP) and Its Impact on the U.S. Power Grid* (Meta-R-321) Metatech Corporation (January 2010).

[28] EMP Commission *Executive Report*, op. cit., p. 1.

address major national security threats to the electric power grids and other national critical infrastructures. Using FERC and NERC to achieve this level of national security is beyond the purpose for which those organizations were created and has proven to be fundamentally unworkable. New institutional arrangements are needed to advance preparedness to survive EMP and related threats to our critical national infrastructures.

We recommend that U.S. military forces and critical national infrastructures be protected from EMP as outlined in the EMP Commission's classified reports and unclassified reports provided in 2004 and 2008. EMP protection of military systems and civilian/military critical national infrastructures can be achieved cost-effectively by a combination of operational procedures and physical hardening. It is not necessary to harden everything. Selective hardening of key critical nodes and equipment will suffice. Threat parameters are 200 kilovolts/meter for E1 EMP and 85 volts/kilometer for E3 EMP. Critical national infrastructures are already adequately protected from E2 EMP, equivalent to lightning.

We recommend, given the proximity and enormity of the threat from EMP and Combined-Arms Cyber Warfare, the President exercise leadership to implement immediate, mid-term, and long-term steps to deter and defeat this existential threat:

Immediately:

We recommend that the President declare that EMP or cyber-attacks that blackout or threaten to blackout the national electric grid constitute the use of weapons of mass destruction that justify preemptive and retaliatory responses by the United States using all possible means, including nuclear weapons. Some potential adversaries have the capability to produce a protracted nationwide blackout induced by EMP or Combined-Arms Cyber Warfare by the use of nuclear or non-nuclear means. A Defense Science Board study *Resilient Military Systems and the Advanced Cyber Threat* (January 2013) equates an all-out cyber-attack on the United States with the consequences of a nuclear attack, and concludes that a nuclear response is justified to deter or retaliate for cyber warfare that threatens the life of the nation: "While the manifestation of a nuclear and cyber-attack are very different, in the end, the existential impact to the United States is the same."

We recommend that the President issue an Executive Order, provided to the previous White House, titled "Protecting the United States from Electromagnetic Pulse (EMP)". Among many other provisions to protect the nation from EMP on an emergency basis, the Executive Order would instantly mobilize a much needed "whole of government solution" to the EMP and combined-arms cyber threat: "All U.S. Government Departments, Agencies, Offices, Councils, Boards, Commissions and other U.S. Government entities…shall take full and complete account of the EMP threat in forming policies and plans to protect United States critical infrastructures…" Protecting the electric grids and other critical infrastructures from the worst threat—nuclear EMP attack—can, if carried out in a system-wide, integrated approach, help mitigate all lesser threats, including natural EMP, man-made non-nuclear EMP, cyber-attack, physical sabotage, and severe terrestrial weather.

We recommend that the President direct the Secretary of Defense to include a Limited Nuclear Option for EMP attack among the U.S. nuclear strike plans, and immediately make targeting and fusing adjustments to some of the nuclear forces needed to implement a nuclear EMP attack capability.

We recommend that the President direct the Secretary of Defense to use national technical means to ascertain if there is a nuclear weapon aboard North Korea's KMS-3 or KMS-4 satellites that orbit over the United States. If either or both of these satellites are nuclear-armed, they should be intercepted and destroyed over a broad ocean area where an EMP resulting from salvage-fusing will do the least damage to humanity.

We recommend that the President direct the Secretary of Defense to post Aegis ships in the Gulf of Mexico and near the east and west coasts, to search for and be prepared to intercept missiles launched from freighters, submarines, or other platforms that might make a nuclear EMP attack on the United States. U.S. National Missile Defenses (NMD) are primarily located in Alaska and California and oriented for a missile attack coming at the U.S. from the north, and are not deployed to intercept a short-warning missile attack launched near the U.S. coasts.

We recommend that the President direct the Secretary of Homeland Security to harden the FirstNet emergency communications system against EMP.

We recommend that the President initiate training, evaluating, and "Red Teaming" efforts to protect the U.S. and in the event of an EMP attack to respond, and periodically report the results of these efforts to the Congress.

Mid-Term:

We recommend that the President direct the Secretary of Defense to deploy Aegis-ashore missile interceptors along the Gulf of Mexico coast to plug the hole in U.S. missile defenses. The U.S. has no Ballistic Missile Early Warning System radars or missile interceptors facing south, and is largely blind and defenseless from that direction, including to missiles launched from submarines or off ships, or from a nuclear-armed satellite orbiting on a south polar trajectory.

We recommend that the President direct the Secretary of Defense to develop a space-surveillance program to detect if any satellites orbited over the United States are nuclear-armed, and develop space-interception capabilities to defend against nuclear-armed satellites that might make an EMP attack.

We recommend that the President direct the Nuclear Regulatory Commission to launch a crash program to harden the over 100 nuclear power reactors and their spent fuel storage facilities against nuclear EMP attack. Nuclear power reactors typically only have enough emergency power to cool reactor cores and spent fuel rods for a few days, after which they would "go Fukushima" spreading radioactivity over much of the United States.

Long-Term:

We recommend that the President through his Executive Agent protect elements of the national electric grids, the keystone critical infrastructure upon which all other critical infrastructures depend. Priority should be given to elements that are difficult and time-consuming to replace. Such elements can be protected from EMP at very low cost relative to the costs of an EMP catastrophe, and paid for without federal dollars by a slight increase in user electric rates. **We recommend that a similar approach be taken to key elements of the national telecommunications infrastructure and other national critical infrastructures.**

We recommend the development and deployment of enhanced-EMP nuclear weapons and other means to deter adversary attack on the United States. Enhanced-EMP nuclear weapons, called by the Russians Super-EMP weapons, can be developed without nuclear testing.

We recommend strengthening U.S. ballistic missile defenses—including deployment of space-based defenses considered by the Strategic Defense Initiative— and that these be designed and postured to also protect the U.S. from EMP attack.