WHITE PAPER

A Near-Term Strategy to Counter the EMP Threat

Henry F. Cooper and Robert L. Pfaltzgraff, Jr.

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Independent Working Group

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Abstract

For decades, the United States has been underestimating, even ignoring threats that can produce irreversibly devastating consequences for U.S. security and well-being. A growing number of states have acquired – or may shortly acquire – ballistic missiles outfitted with nuclear warheads that could be launched against the highly vulnerable U.S. electronic infrastructure upon which our very survival depends. Non-state armed groups also may acquire such weapons. Even a single nuclear warhead with negligible targeting accuracy could be detonated a hundred miles or so over the United States to produce a devastating electromagnetic pulse (EMP), and the resulting chaos could lead to the death of several hundred million Americans within a year.

Of key concern is at least three categories of attack scenarios that now constitute this existential threat: 1) nuclear-armed intercontinental ballistic missiles (ICBMs) launched over the North Pole by North Korea or Iran; 2) nuclear-armed short-, medium-, or intermediate-range missiles launched by rogue states or their terrorist surrogates from ships off the east or west coasts of the United States, and particularly from the Gulf of Mexico or Latin America; and 3) a nuclear-armed satellite, called during the Cold War a Fractional Orbital Bombardment System (FOBS) launched over the South Pole by North Korea or Iran. A less conventional fourth scenario could involve a ballistic missile launched from an aircraft to detonate its warhead high over the central United States. (The United States launched a *Minuteman* ICBM from a cargo plane in the late 1960s.)

The EMP created by each of these high altitude EMP (HEMP) attack scenarios could by itself alone result in irreparable damage to the currently unhardened U.S. electronic-centric critical civil infrastructure and the ability to assure the mission-essential capability of U.S. military forces, many of which depend on the U.S. civil infrastructure. Of greatest concern is the currently unhardened electric power grid upon which all U.S. critical electrical infrastructure depends. No national strategy presently addresses these threats or supports effective countermeasures.

To begin countering these HEMP threats immediately, we recommend expedited effective employment of: 1) already operational U.S. Navy *Aegis* ballistic missile defense (BMD) ships and soon to be operational *Aegis Ashore* BMD sites combined with 2) effective early warning, battle management, and command, control, communications, and intelligence (EW/BM/C^{3}I) capabilities. These systems

would of course be integrated with other current and more capable future BMD systems.

Existing and planned operationally flexible U.S. Navy *Aegis* BMD ships and their *Standard Missile*-3 (SM-3) family of interceptors can, if properly stationed with the needed warning and track information, immediately begin countering the HEMP threats. These capabilities can be augmented with U.S.-based *Aegis Ashore* BMD systems now planned to begin operations in Romania (2015) and Poland (2018). With needed funding, these *Aegis Ashore* components (that fit in a football field size area) can be deployed on the same time frame near U.S. coasts, particularly near the Gulf of Mexico.

Existing and upgraded EW/BM/C^3I can improve interoperability among all stakeholders and cue effective BMD systems to intercept threatening ballistic missiles, while increasing maritime domain awareness to help U.S. naval assets locate and interdict a threatening vessel approaching U.S. territorial waters close enough to launch such an EMP attack. Enhanced early warning and tracking information is especially important to enable an effective defense against a FOBS attack, since today's coverage in the southern hemisphere is not robust.

Our proposed near-term BMD architecture would help protect the American people against direct attack – a particularly important fact given the shortcomings of the current U.S. ground-based missile defense system in Alaska and California and the time required to develop a significantly improved capability. At the same time, it could begin countering the HEMP threat. A key objective of this architecture and supporting technologies is also to introduce uncertainties into an attacker's calculation of success, and thereby to aid in deterring such an attack in the first place. Benefits of this architecture could be evident within the next 1-3 years.

Our principal recommendations are to:

- Provide funding to deploy additional *Aegis* BMD SM-3 IB interceptors and to accelerate development of the SM-3 IIA missile to improve capabilities to counter ICBMs and in some cases improve ascent-phase intercept capabilities to counter some HEMP threat scenarios, e.g. from North Korea or FOBS launched from Iran or North Korea.
- Develop in 2014 the concept of operations and assessment of the number and type of *Aegis* BMD ships and *Aegis Ashore* sites needed for deployment along the east, west, and the Gulf of Mexico coasts of the United States to counter the HEMP and

FOBS threat from the south; and begin deploying/stationing those assets as soon as practical.

- Augment, beginning in 2014, U.S. EW/BM/C^{3}I assets and capabilities to provide maritime domain awareness to identify and prevent suspicious vessels from approaching in sufficient proximity to U.S. shores to initiate an HEMP attack, and if unsuccessful, to provide early warning of such an attack, as well as for a FOBS attack emanating from a southern polar trajectory where U.S. radar/sensor coverage is less focused.
- In conjunction with these EW/BMC^{3}I improvements, deploy appropriate forward based radars (e.g., TPY-2 in the Philippine Islands) to enable an exo-atmospheric anti-FOBS capability for our *Aegis* BMD ships in the Pacific Ocean and our ground-based interceptors (GBIs) at Vandenberg AFB, California.
- In light of the abbreviated EMP-attack warning time (1-3 minutes or less) required to enable ascent- or boost-phase intercept, develop the concept of operations needed to assure pre-delegation authority for the on-the-scene commander to launch anti-HEMP interceptors, especially in case of FOBS attack scenarios. Among these conditions, develop diplomatic initiatives to support *Aegis* BMD system operations near the coasts of North Korea and Iran to enable the inherent boost-phase intercept capability of the SM-2 Block IV endo-atmospheric interceptor.
- Harden a minimum essential subset of the U.S. electric power grid to assure that the nation's critical infrastructure can be rapidly reconstituted following a successful HEMP attack, should the defense fail – or in the case of a natural EMP event associated with a solar storm against which the hardening of the electricity power grid would be indispensable. Thus a strategy to counter natural and man-made EMP threats must include hardening electricity infrastructure *and* a robust missile defense against an EMP attack.

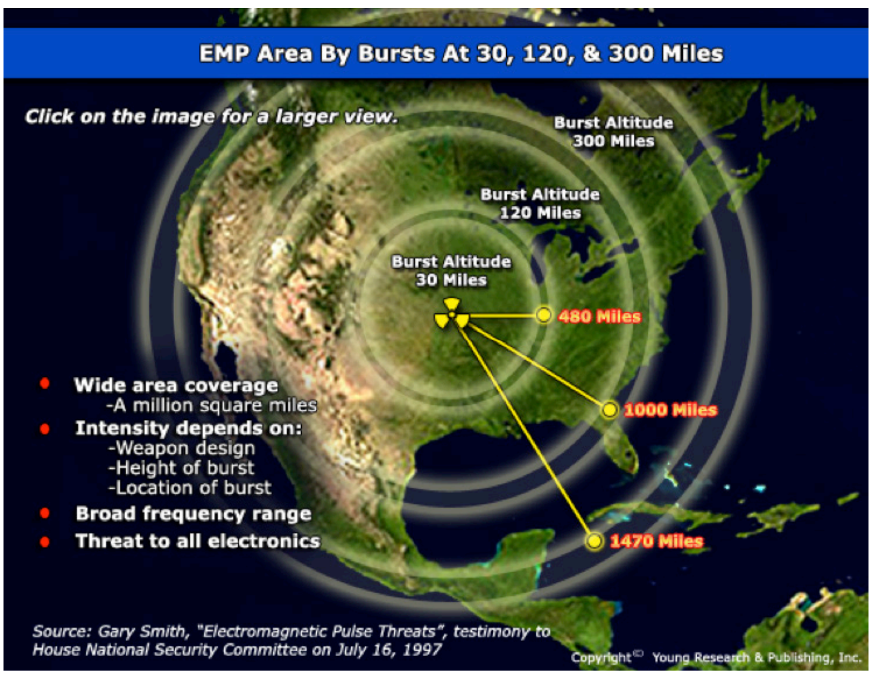
As Yet Unaddressed Existential Manmade and Natural EMP Threats

The United States has overlooked several electromagnetic pulse (EMP) – manmade and natural – threat scenarios that can have devastating and possibly irreversible consequences for U.S. security and the well-being of all Americans. If unaddressed, hundreds of millions of Americans could perish within a year after any one of several credible attack scenarios. They include the possibility of a devastating EMP attack as well as a solar eruption that unleashes EMP against vulnerable infrastructure in the United States and elsewhere.

The High Altitude EMP Threat

An unprecedented number of states have now acquired – or are about to acquire – missiles and satellites that could carry nuclear warheads to be detonated high over the United States with devastating consequences for the currently highly vulnerable U.S. electronic infrastructure. The high-altitude electromagnetic pulse (HEMP) produced by such a detonation above the central continental United States could cause catastrophic damage over a large area as illustrated in Figure 1.

FIGURE 1



This figure from 1997 testimony before the House National Security Committee, illustrates that the HEMP threat has been well understood for a long time. But it was for many years cloaked in a veil of secrecy associated with U.S. concerns about the ability of its strategic systems to survive, operate through and retaliate after a major Soviet nuclear attack. The Pentagon spent billions to assure this ability after discovering the implications of HEMP on a 1962 high altitude nuclear test, Starfish Prime.[1] But beyond key military systems, critical infrastructure was not hardened – and those vulnerabilities were not understood by most civil authorities, as essentially all aspects of U.S.

1 Significant consequences from EMP were unanticipated from Starfish Prime, a 1962 nuclear detonation about 400 kilometers above Johnston Island in the Central Pacific. However, effects, felt 900 miles away in Hawaii, included failure of street lighting systems, tripping of circuit breakers, triggering of burglar alarms, and damage to a telecommunications relay facility. We learned after the Cold War that 1962 Soviet high altitude nuclear tests damaged overhead and underground buried cables out to 350 miles and caused surge arrester burnout, spark-gap breakdown, blown fuses, and power-supply interruption. Modern electronics would have suffered greater damage.

society grew ever more dependent on highly vulnerable electronic infrastructure.[2] Furthermore, most of the American public has long been uninformed about this existential threat to their very survival.

After the hearings associated with Figure 1 presented the seriousness of the HEMP threat, key congressional leaders became concerned and persuaded Congress to charter a nonpartisan expert commission to fully explore the issue and recommend remedial action.

The Commission to Assess the Threat to the United States of Electromagnetic Pulse (EMP) Attack, or EMP Commission (home page: http://www.empcommission.org/), provided its first report in 2004, with its bottom lines in an unclassified executive summary. The entire Congress was briefed in a closed session, but essentially all key data remained classified, inhibiting broader dissemination of much of the supporting information. Since 2008, after the EMP Commission obtained approval for public release, most of the pertinent information on the EMP threat and lessons for hardening electronic systems has been available to the public.

Based on the commission reports[3] and other information, the EMP from a high altitude nuclear burst consists of three components or pulses:

- E1 in about a hundredth-of-a-microsecond generates an "electromagnetic shock" that essentially instantaneously damages, disrupts, and destroys electronics and electronic systems over a very large area from a nuclear burst at an altitude of twenty-five miles to possibly the entire continental United States if detonated at an altitude of a hundred or so miles. Most mechanisms designed to defend against lightning strikes will not withstand this assault. The E1 pulse couples effectively to short and long conductors, for example computer USB cables, radio antennas, long-haul telecommunications lines and electric power transmission lines. It is capable of causing upset or burnout of electrical and electronic systems in general, placing trillions of dollars' worth of electronics at risk. Of particular concern, E1 will destroy Supervisory Control and Data Acquisition (SCADA) components critical to our national infrastructure. Critical components must be stockpiled to be used in a viable restoration program.

3 According to the 2008 *Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack*, a single nuclear weapon exploded at high altitude above the United States will interact with the Earth's atmosphere, ionosphere, and magnetic field to produce an electromagnetic pulse radiating down to earth and additionally create electrical currents in the Earth. EMP effects are both direct and indirect. The former are due to electromagnetic "shocking" of electronics and stressing of electrical systems, and the latter arise from the damage that "shocked" upset, damaged, and destroyed electronics controls then inflict on the systems in which they are embedded. See http://www.empcommission.org/docs/A2473-EMP_Commission-7MB.pdf.

2 The destruction and mayhem caused by an EMP explosion would be far more substantial today given the ubiquity of more fragile electronics and our greater reliance on them to run critical infrastructures. Moreover, an EMP burst could directly affect the 3,000 commercial and military flights airborne over the United States at any given time, possibly causing all or most of them to crash. Most of those aircraft, equipped with electronic-interface fly-by-wire control systems, would become unguided missiles, plummeting to Earth and leading to many thousands of fatalities and enormous physical damage. U.S. satellites, both civilian and military, are vulnerable to a range of attacks that include EMP, especially in low-Earth orbits. The national security and homeland security communities depend on commercial satellites for critical activities, including direct and backup communications, emergency response services, and continuity of operations during emergencies.

- E2 has effects similar to lightning and also spreads across the nation in a fraction of a second, slightly later than E1, on the order of microseconds to milliseconds after the detonation. Systems with built-in protection against occasional lightning strikes would be expected to avoid serious damage, but synergistic effects could inflict more damage than E1 alone. Stockpiling critical components for a restoration program would be prudent.
- E3 is a longer pulse, up to several minutes duration, and couples significant currents in very long line conductors (longer than ~1km) such as in the electric power grid, long communication lines, and pipelines. The effects are similar to those produced by intense solar storms. Of particular concern are E3 currents on the long transmission lines that feed into thousands of electric power grid substations, focusing destructive energy on critically important components such as the Extra High Voltage (EHV) transformers – which are currently vulnerable and are not easily replaced. They take many months to build (by hand outside of the United States) and, without electricity, transportation would be difficult if not impossible. These components must be hardened to survive if the grid is to remain viable.

E1 and E3 are of greatest concern since each effect alone has the potential to collapse the nation's electrical grid for long periods and thus inflict catastrophic damage on the United States. The sequential timing of the three components permits an accumulation of effects that may cause more damage than would each alone. Damage from each strike amplifies the damage caused by each succeeding strike. It is important to note that if the grid is hardened to HEMP effects, it will also be hardened to the natural EMP discussed in the following section – the converse is not true.

A thorough plan is needed to assure the survival and viability of the minimal essential components of the grid to these HEMP effects – with priority assigned on the basis of assuring an ability to restore other damaged portions of the grid. Other essential components not expected to survive the HEMP should be stockpiled for re-establishing the grid.

The EMP Commission report discusses these effects in detail, or see a recent informative paper by Dr. George Baker, who for several years oversaw the Pentagon's EMP research and development programs and served on the Commission staff.[4]

In summary, the EMP Commission noted that even a single warhead poses an HEMP threat that could have catastrophic consequences. Terrorists or states could launch an unsophisticated missile to detonate its nuclear warhead at a significant altitude to gain high political-military payoff as an asymmetrical capability, overwhelming U.S. military strength with a single blow where the United States is currently very vulnerable, with widespread cascading consequences. The United States is heavily dependent on electronics, energy, banking, telecommunications networks, transportation systems, the movement of inventories, and food processing and distribution capabilities, which constitute such points of vulnerability.

Disabling even a portion of the U.S. critical infrastructure, such as telecommunications or electricity, would have severe consequences from which an advanced, technologically dependent society such as the United States might not easily recover. The services essential to coping with the consequences of a terrorist attack, such as hospitals and emergency services, might be themselves disabled and therefore unavailable when and where they were most needed.

A HEMP attack on the United States would also have global consequences, extending from Europe to Northeast Asia and in and beyond this hemisphere given America's interdependence with other economies. By the same token a HEMP attack against other technologically advanced economies, such as Japan or Europe, would have major effects in the United States.

We have known for years that many nations can acquire such HEMP attack capabilities and are likely seeking to obtain them. For example, during the May 1999 NATO air campaign against Serbia, members of the Russian Duma, meeting with U.S. congressional counterparts, described the paralyzing effects of a HEMP attack on the United States. Iran is reported to have tested whether its ballistic missiles could be detonated by remote control while still at high-altitude.[5] One plausible explanation for such tests is that Iran is developing the capability to explode a high-altitude nuclear weapon to destroy electronic and other critical infrastructures.[6]

And some believe that North Korea has tested nuclear weapons especially designed to enhance EMP effects.[7] If so, they likely have shared this knowledge with Iranian scientists who are present at the North Korean tests – as well as the North Korean ballistic missile tests.

We cannot afford continued delay without a countervailing strategy that includes an effective

4 George H. Baker. "National Infrastructure Protection Priorities for Nuclear Electromagnetic Pulse (EMP) and Solar Storm Geomagnetic Disturbance Catastrophes," *High-Impact Threats to Critical Infrastructure: Emerging Policy and Technology*, DuPont Summit Proceedings, Washington, DC: Westphalia Press 2013. See: http://works.bepress.com/george_h_baker/39

5 Jon Kyl, "Unready for This Attack," *Washington Post*, April 16, 2005.

6 See *WorldNetDaily.com*, "From Joseph Fareh's G2 Bulletin: Iran plans to knock out U.S. with 1 nuclear bomb," April 25, 2005, http://www.worldnetdaily.com/news/article.asp?ARTICLE_ID=43956 (as of November 12, 2008).

7 "North Korea Vows to use 'New Form' of Nuclear Test" by Choe Sang-Hun, *The New York Times*, March 30, 2014. See http://www.nytimes.com/2014/03/31/world/asia/north-korea-promises-new-form-of-nuclear-test.html?_r=0 .

missile defense to counter an EMP attack. This U.S. vulnerability can be exploited by states and terrorists to our great disadvantage.

Solar Storms: Coronal Mass Ejection and Geomagnetic Disturbance Threats

The comprehensive 2008 EMP Commission report identified a "natural" EMP threat associated with periodic solar storms. If such a Coronal Mass Ejection (CME) interacts with the Earth's geomagnetic field, it will cause a Geomagnetic Disturbance (GMD) that can produce one of the most damaging components of the nuclear EMP threat, E3.

This natural EMP-threat event *will occur* someday. Indeed, it is overdue given estimates that one of the regularly occurring CMEs envelops planet Earth every hundred or so years; the last such occurrence was the so-called Carrington event in 1859, named after English amateur astronomer Richard C. Carrington who observed and documented its occurrence and effects.

The Carrington GMD damaged telegraph lines, including our first undersea cable connecting the United States and Europe. Fortunately, society was then sustained by indigenous agriculture that provided the essentials for human life – and little dependence on electricity – so there were no major consequences. A similar GMD today would be far more consequential given our dependence on electricity and a just-in-time economy dependent on modern electronics.

Notably, the July 13, 2013 *Washington Post* carried an extensive multi-page article in its business section discussing in detail this CME/GMD threat.[8] The article not only discussed the nature of this "space weather" threat, but also that it is now being considered in day-to-day operations of scores of businesses and government agencies; that airlines such as Delta plan to reroute flights in the case of related emergencies; that the U.S. military has begun to realize that space-weather blips can disrupt communication in the heat of battle; and that electric-grid operators are devising plans to reroute currents through their systems to brace for solar storms.

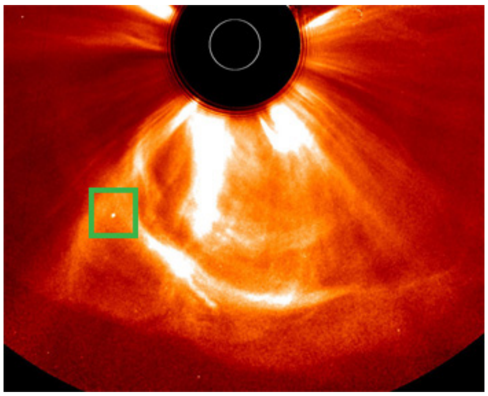
However, the article also implied that these remedial measures may not be, and probably are not, adequate. In an understatement, the article noted that preparing for such disruptions is not easy and that, just as interest in space weather is surging, the United States is facing the loss of key monitoring satellites in the coming years. Budget cuts mean that aging systems are not being replaced, while scientists are rushing to plug worrisome gaps in their knowledge about these storms.

8 "When Space Weather Attacks," by Brad Plumer, *The Washington Post*, June 13, 2013. See http://www.washingtonpost.com/blogs/wonkblog/wp/2013/07/13/when-space-weather-attacks/ .

In emphasizing this point, the article referenced a June 2013 National Oceanic and Atmospheric Administration conference on space weather[9] at which Daniel N. Baker of the University of Colorado reported that the sun had unleashed another large coronal mass ejection in July 2012 that traveled at speeds comparable to the Carrington Event of 1859 and just missed the Earth.

FIGURE 2

This image captured on July 23, 2012, at 12:24 a.m. EDT, shows a coronal mass ejection that left the sun at the unusually fast speeds of over 1,800 miles per second. (Image credit: NASA STEREO). Earth is the small dot in the green square.



As shown in figure 2, this July 23, 2012, emission crossed the Earth's orbit just nine days behind us.[10] (The small white dot in the green square is the Earth.) Had it enveloped the Earth, vulnerable Extremely High Voltage (EHV) transformers of our electric power grid likely would have been damaged beyond repair. Most critical nodes of the grid have no spares, so the grid likely would have collapsed without hope of revival – with the disastrous consequences suggested by William Forstchen's novel, *One Second After* – and within a year hundreds of millions of Americans could die – among many others around the world who are also dependent on electricity for survival.[11]

Subsequent to the EMP Commission's reports, several other studies – including by the National Academy of Sciences – have validated the commissioners' conclusions and recommendations, in part or whole.[12] And while awareness of this existential threat is growing, little if anything has been done to deal with it, whether it comes from natural or manmade sources.

Notably, Lloyds of London in 2013 conducted an important analysis of the consequences of a CME/GMD event that impacts the northeastern United States and Canada.[13] They noted that, "While the probability of an extreme storm occurring is relatively low at any given time, it is almost inevitable that one will occur eventually. Historical auroral records suggest a return period of 50 years for Quebec-level storms and 150 years for very extreme storms, such as the Carrington Event that occurred 154 years ago." Their report observed that such a storm, which could occur as early as 2015, could leave 40-60 million Americans without electricity for 16 days to 1-2 years – with major implications for the insurance industry. And for all Americans!

There is a tendency to give priority to hardening to counter the GMD threat, which is perhaps understandable for the insurance community

9 "Simulation of the 23 July 2012 extreme space weather event: What if this extremely rare CME was Earth directed?," *Space Weather*, Vol. 11, 671–679, 2013, see http://onlinelibrary.wiley.com/doi/10.1002/2013SW000990/pdf .

10 Reference to 2012 event . . . http://newscenter.berkeley.edu/2014/03/18/fierce-solar-magnetic-storm-barely-missed-earth-in-2012/ .

11 See http://www.amazon.com/One-Second-After-William-Forstchen/dp/0765356864 .

12 In a short monograph entitled *Guilty Knowledge: What the US Government Knows about the Vulnerability of the Electric Grid, But Refuses to Fix*, The Center for Security Policy has published pertinent excerpts from 11 reports including: 1&2) *The Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack* (2004 and 2008); 3) *Severe Space Weather Events: Understanding Societal and Economic Impacts, A Report of the National Research Council of the National Academies* (2008); 4) *The Final Report of the Congressional Commission On the Strategic Posture of the United States* (Excerpts) (2009); 5) *Intentional Electromagnetic Interference (IEMI) and Its Impact on the U.S. Power Grid, Metatech Corporation* (2010); 6) *High-Impact, Low-Frequency Event Risk to the North American Bulk Power System – A Jointly-Commissioned Summary Report of the North American Electric Reliability Corporation and the U.S. Department of Energy's November 2009 Workshop* (2010); 7) *Large Power Transformers and the U.S. Electric Grid*; 8) *Infrastructure Security and Energy Restoration Office of Electricity Delivery and Energy Reliability, U.S. Department of Energy* (2012). See http://www.centerforsecuritypolicy.org/2014/03/12/guilty-knowledge/ .

13 *Solar Storm Risk to North America*, by Lloyd's and Atmospheric and Environmental Research, Inc., 2013. See www.lloyds.com/~/media/lloyds/reports/emerging%20risk%20reports/solar%20storm%20risk%20to%20the%20north%20american%20electric%20grid.pdf .

since HEMP might be considered an act of war, not covered by insurance. But doing so without considering the HEMP threat would be most unwise, because the HEMP involves three components: E1, E2, and E3 – while GMD threats are similar only to the E3 component, and both indeed pose a serious threat to the EHV transformers.

But the HEMP E1 component can also irreversibly damage the EHV transformers essential to the viability of the grid, a fact that should not be ignored when hardening the grid. This HEMP "high frequency" component will damage the tiny computers in most of the nation's critical infrastructure – including modern systems providing communications, transportation, banking, security, etc. While much of the infrastructure may be replaced by stockpiled components, if the EHV transformers are disabled from the E1 component, they could not be replaced.

Thus, simply hardening the grid to a Carrington level GMD (or greater) is a necessary but not sufficient condition to assuring its survival in case of a HEMP attack. Conversely, while it is important to defend against a HEMP attack, no defense is perfect – so the grid should be hardened to survive and operate through – or be reinstated after – a HEMP attack. If that is done, together with the missile defense recommendations of this White Paper, then both natural and manmade threats will be countered.

Positive signs are found in a growing awareness of the lack of resilience of the electric power grid to a number of threats, including beyond the natural and manmade EMP threats, physical and cyber attacks. But thus far, little U.S. attention has been paid to either the manmade or natural existential EMP threat.

Some favor dealing first with the natural GMD threat because they think that seeking to counter the HEMP threat is only a stalking horse for developing more ballistic missile defense systems. But this approach is short sighted and would leave a serious threat unaddressed.

Hardening the grid only to GMD threats would not only leave the grid vulnerable to HEMP, but the false sense of security would leave the American people vulnerable to several ballistic missile attack scenarios that are not now dealt with by the currently deployed BMD systems, as discussed below.

Inadequately Addressed Ballistic Missile Threat Scenarios

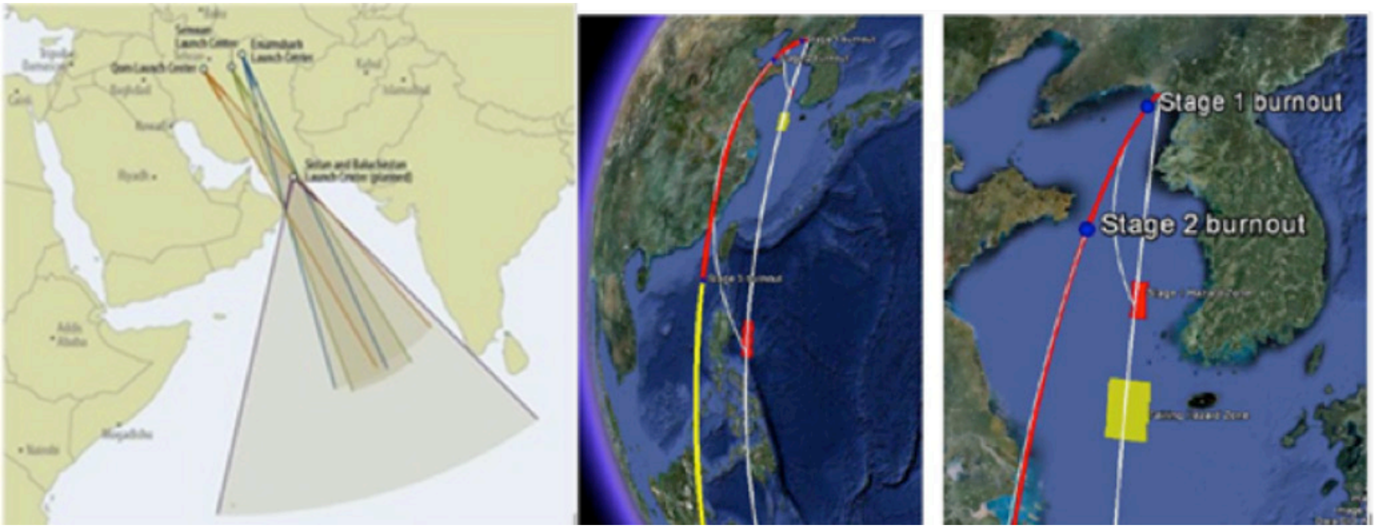
This new security setting contains at least three major categories of emerging proliferation threats and challenges that have not received adequate attention in light of the devastating potential of the high altitude detonation of only one or just a few nuclear warheads over the United States.

1. ***The possibility of a nuclear ICBM launched over the North Pole by North Korea or Iran.*** The recent power struggle in North Korea, together with the leadership purges directed by North Korean leader Kim Jong Un, further magnifies the unpredictable and impulsive nature of this regime. North Korea is already in possession of a dozen or so nuclear warheads, has test-fired long-range missiles, and is determined to master nuclear warhead technology. Even in the event that a comprehensive nuclear agreement is reached with Iran that halts or significantly slows its nuclear program, Tehran will still be in possession of a rapid nuclear weapon breakout capability as well as the single largest – and growing – ballistic missile inventory in the Middle East with the ability to threaten Europe, the United States and its forward deployed and power projection forces. Furthermore, there are reports of increasing cooperation between Pyongyang and Tehran on military technologies, including nuclear weapons and ballistic missiles.
2. ***Nuclear-armed short-, medium-, or intermediate-range missiles launched from ships off our east or west coasts, and especially from the Gulf of Mexico or from Latin America.*** These attacks could be conducted by rogue states and/or their surrogate terrorist groups that may have growing access to these types of weapon systems in the years ahead. The Pentagon apparently has ignored this threat, especially of a ballistic attack from the south – from a vessel in the Gulf of Mexico or from Latin America. Our *Aegis* BMD ships, which operate along our eastern seaboard but not in the Gulf, have the inherent capability to defend against these attack scenarios.
3. ***A nuclear-armed satellite attack, like the Soviets planned for their 1960s fractional orbital bombardment system (FOBS), from over the South Polar region.*** First developed by the Soviet Union during the Cold War, FOBS is a weapon system in which a nuclear warhead would be inserted into a steeply inclined

FIGURE 3

Iran has launched satellites into orbit to the south over the South Pole

North Korea used three-stage rockets to launch satellites southward into polar orbit over the South Pole



low-altitude polar orbit that would be difficult to detect because of its polar flight trajectory from the southern hemisphere where U.S. early-warning capabilities are less robust. As shown in figure 3, North Korea and Iran have launched satellites to their south on paths that could be changed slightly so that they pass over the United States in their first orbit to detonate a nuclear warhead and produce the HEMP effects described previously. Because U.S. missile defense systems, especially the GBIs in Alaska and California, were designed against a long-range missile attack from the north, we are highly vulnerable to this plausible but so far ignored attack from the south.

Any of these attack scenarios could create HEMP with potentially irreparable damage to our critical electronic infrastructure, especially the electric power grid upon which our electronic systems depend. It would threaten mission-essential military capabilities such as command and control, early-warning, reconnaissance/surveillance, navigation, and damage assessment to U.S. forward deployed and power projection forces.

No national strategy addresses either the HEMP threat or underwrites a serious program to counter the delivery of HEMP by a ballistic missile launched from a vessel off our coasts or from a nuclear-armed satellite launched over the South Pole toward the United States.

Urgently needed is a comprehensive strategy to protect vitally important electronic infrastructure, including our electricity power grid, from EMP-type attacks.

Possible Near-Term Countermeasures to the HEMP Threat

The National Defense Authorization Act (NDAA) for Fiscal Year 2014 directs the Secretary of Defense to provide a report on future options for defending the U.S. homeland, including an assessment of the ballistic missile threat from North Korea and Iran through 2022. To be included is an assessment of the effectiveness of current and planned U.S. BMD systems against that threat.

Congress also stipulated that the report include recommended improvements that could result from additional ground based interceptors and sensors, additional ground based BMD sites, enhancements in operations effectiveness, and, in view of the above summary of existential threats, most notably:

> *"[T]he potential for future enhancement and deployment of the [Navy's] Standard Missile-3 Block IIA interceptor to augment United States homeland ballistic missile defense; missile defense options to defend the United States homeland against ballistic missiles that could be launched from vessels on the seas around the United States, including the Gulf of Mexico, or other ballistic missile threats that could approach the United States from the south, should such a threat arise in the future."*

The Act directed the Department of Defense to evaluate the advantages and disadvantages of recommended alternatives, including considerations of technical feasibility; operational effectiveness and utility against the projected future threat; cost, cost effectiveness, and affordability; and agility to respond to changes in future threat evolution.

The NDAA directive to examine how the SM-3 Block IIA interceptor might contribute to U.S. homeland defense is well framed, as discussed below. This is also a well-deserved vote of confidence for the *Aegis* BMD development team which has accumulated a 28-successes-out-of-34-attempts test record, all conducted by operational crews.[14] As discussed below, the potential role of all *Standard Missile* options should be considered, including several that are new.

Near-Term Counters to ICBM Attacks from the North

The first of these new roles is for the SM-3 to directly support the defense of the U.S. homeland

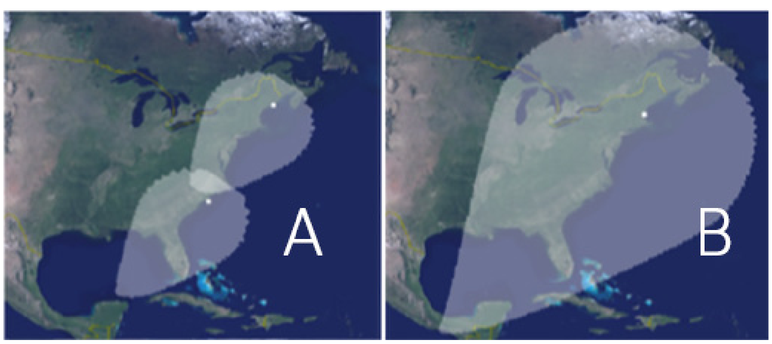
14 Authoritative witness to this proven capability was provided by then-Under Secretaries of Defense Michele Flournoy and Ashton B. Carter in their June 17, 2013 *Wall Street Journal* article on "The way forward on Missile Defense:" "The SM-3 version deployed on Navy ships today has hit – within inches – its exact target in nine out of 10 tests. The accuracy of these tests has been confirmed in a variety of ways: by fiber-optic grids that can precisely indicate the point of impact on the target; by images taken from the interceptor in the very last moment before impact (images not available to the public for security reasons); by data from highly accurate radars and airborne sensors; and by extensive rocket sled tests and computer simulations on the ground. All these verification sources confirm that when a missile warhead was hit, it was destroyed. These results have been validated by an independent panel of experts with access to all of the classified and unclassified test data."

– an especially important innovation because the current GBI BMD systems operational in Alaska and California have significant deficiencies in defending the U.S. eastern seaboard, especially against Iranian ICBMs.[15] According to press reports and VADM Syring's recent testimony,[16] the Missile Defense Agency (MDA) is considering several east coast sites to deploy an upgraded version of the GBI system to rectify this shortcoming.

While we would not dispute the wisdom of this initiative, we strongly advocate nearer-term relatively inexpensive defense options made possible by the well tested operational *Aegis* BMD system – now deployed on thirty U.S. *Aegis* cruisers and destroyers around the world (and currently programmed to grow to forty-three by 2019).

At any time, it is anticipated that 4-6 of these ships are in transit along the eastern seaboard of the United States or in an east coast port as part of their regular deployments. With appropriate operations training, the crews on these *Aegis* BMD ships are inherently capable of defending the east coast against ICBMs, if relatively inexpensive radars are deployed to provide track information to cue the existing *Standard Missile*-3 (SM-3) interceptors into the battle space where they can intercept an incoming warhead from over the North Polar regions.

FIGURE 4



For example, map A of figure 4, provided by IWG member Retired VADM J.D. Williams,[17] illustrates the defensive coverage against Iranian ICBMs that can be provided by the currently deployed SM-3 Block IA and IB interceptors if two radars are provided – as illustrated by the "white dots" for one in Maine and one near or in Camp Lejeune, North Carolina. Map B illustrates the coverage that would be available once these ships carry the faster SM-3 Block IIA under development to be operational in Poland by 2018.

With one radar in Maine, the northeastern seaboard as far south as the National Capitol Region can be defended by a single currently operational *Aegis* BMD ship in or near Norfolk, VA. According to Retired Vice Admiral Rodney Rempt,[18] the first director of the Navy's *Aegis* BMD program, an existing TYP-2 radar (being produced for multiple deployments) could be deployed in Maine for $20 million. (Building a new TYP-2 radar costs about $300 million.) Everything else is available for employing this near-term defense. A second radar on Camp Lejeune, North Carolina would permit a second

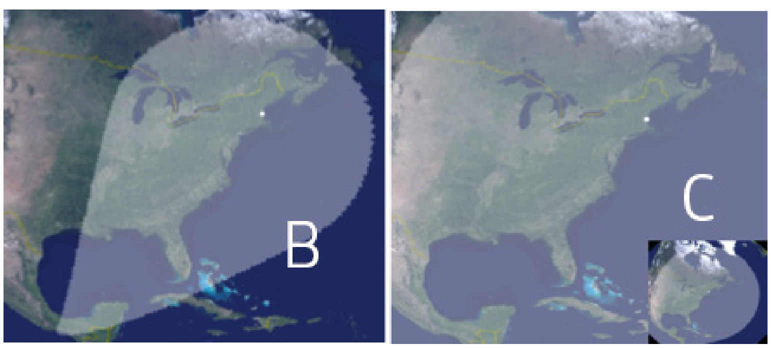
15 GMD testing indicates a 50-percent kill rate (8 intercepts of 16 attempts), with the last three tests as failures.
16 VADM James D. Syring, MDA Director, March 25, 2014 Testimony to the House Armed Services Committee. See http://docs.house.gov/meetings/AS/AS29/20140325/101945/HHRG-113-AS29-Wstate-SyringUSNavyJ-20140325.pdf
17 VADM J.D. Williams, Personal Communication, based on analyses by MIT/Lincoln Laboratories among others.
18 Personal communication from VADM Rod Rempt.

existing *Aegis* BMD ship to defend the rest of the eastern seaboard against Iranian ICBMs. Last March, the *Huntsville Times* reported that Raytheon was six months ahead of schedule in producing TYP-2 radars, so implementing this recommendation should not be a challenge.[19]

Once the SM-3 Block IIA is available in 2018, additional interceptors for ships operating near our east coast would enable a single such ship to defend the entire eastern seaboard – actually the United States east of the Mississippi River (see map B of Figure 5). An *Aegis Ashore* site (like those being constructed in Romania and Poland together with the *Aegis Ashore* Missile Defense Test Complex in Hawaii) could be located on an appropriate military base for the same effect. Since *Aegis Ashore* development is already near completion, additional costs for such a site should be minimal.

It should be noted that the Block 1A was used in 2008 to shoot down a decaying U.S. satellite – demonstrating an inherent anti-ICBM capability provided required cuing information is available. That is why the TYP-2 radar is a needed component to cue this possible near-term eastern seaboard defense. The Block 1A also was successful in intercepting a more sophisticated target ballistic missile that has yet been demonstrated by the deployed GBI interceptor.

FIGURE 5



The Block IIA improved defensive coverage is because its burnout velocity is about 33 percent greater than the Block 1A or 1B. The defended area increases as the square of the velocity, with an additional potential impact as illustrated in map C of figure 5 by the extra defended area resulting from a further 25-percent increase in burnout velocity. Then, a single east coast *Aegis* BMD ship could defend essentially all of the continental United States from Iranian ICBMs.

Based on research over 20 years ago and confirmed by the Navy 15 years ago, this additional capability – and more – can be achieved with an advanced light-weight kinetic kill vehicle designed specifically for the front end of the SM-3 Block II stack that is compatible with the *Aegis* Vertical Launch System (VLS).

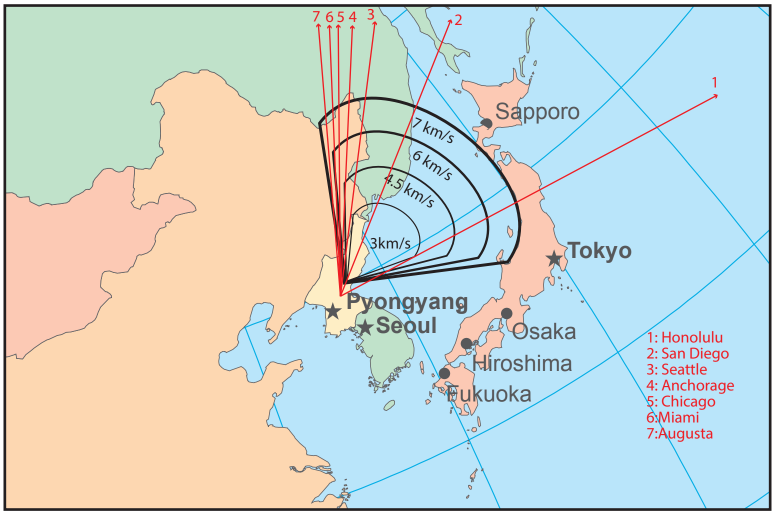
The importance of achieving higher burnout velocities was also illustrated by a 2001 study that considered how *Aegis* BMD ships could shoot down North Korean ICBMs ascending from their launch pads, as illustrated in figure 6.[20] The launch "fans" illustrate areas from which interceptors with various

19 "Raytheon Delivers Ninth AN/TYP-2 Radar to Missile Defense Agency 6 months ahead of schedule," *The Huntsville Times*, Mar. 28, 2014.

20 "The Earliest Deployment Option – Sea-Based Defenses," Henry F. Cooper and J.D. Williams, *Inside Missile Defense*, September 6, 2000.

velocities could engage a nominal *Taepodong* missile launched at San Diego from the western side of North Korea. (Rotating all the launch fans permits one to estimate similar launch areas for defending other U.S. cities as indicated by the red trajectory paths.)

FIGURE 6



The scenarios assume that the interceptors are launched 50 seconds after the *Taepodong* lift off – a challenging but achievable feat – and intercept occurs wherever is kinematically feasible.

The "velocity fans" over the Sea of Japan indicate where *Aegis* BMD ships might operate and have boost- and ascent-phase shots at missiles launched at San Diego.[21] The higher the velocity, the larger the potential operating area. Smaller operating areas would result from a similar set of velocity fans created for boost-phase intercepts only. Notably, the current *Aegis* BMD system does not have a boost-phase intercept capability – that could and should be included in a robust research and development program to make the *Aegis* BMD system all it can be, especially in responding to likely offensive countermeasures.[22]

By rotating the "velocity fans" for boost- and ascent-phase intercept cases around the various (red) flight trajectories, one can make several important observations:

- If based near the North Korean coast, even three km/second interceptors – somewhat slower than the operational SM-3 Block IA/B interceptors – could have ascent-phase intercept opportunities against missiles launched at Hawaii, Alaska, the entire West Coast, the Southwest, and into the Midwest and South-central states. However, they probably would not protect U.S. cities east of a line between Chicago and Miami. Higher velocity interceptors over six km/second could have ascent-phase intercept opportunities for North Korean missiles launched at any U.S. city. Additionally, ships armed with these higher-speed missiles could benefit from a much larger operating area.
- The slowest interceptors would also have boost-phase intercept opportunities against missiles launches at Hawaii, limited parts of the Northwest and along the West Coast. High velocity – and, even more importantly, high

21 Areas in China – and, for high velocity interceptors, in Russia – could provide ascent-phase intercept opportunities for *Aegis Ashore* interceptors based there – an unlikely possibility without a major change in current geopolitical realities.

22 In most missile defense literature, the trajectory of a ballistic missile is described as following three phases: boost, midcourse, and terminal. The boost phase begins immediately after launch, while the booster rocket is burning, emitting bright exhaust gases that are relatively easy for sensors to detect and track – the principal challenges for a boost phase defense is to discriminate between that bright plume and the target rocket – and to intercept it in a very brief time (a minute or so) during which the rocket accelerates to reach its "burnout" velocity and its weapon separates from the launching rocket. The separated weapon then coasts through the much longer midcourse phase in outer space – first ascending (while decelerating because of gravity) to the trajectory's high point, or apogee, and then descending (while accelerating) back toward the earth's atmosphere. During its terminal phase, the weapon descends through the atmosphere to its target. MDA now divides the trajectory into four phases: boost, ascent, midcourse, and terminal (see http://www.mda.mil/system/elements.html), a formulation due in part to the *Aegis* BMD system's successfully tested ascent-phase intercept capability. The "ascent phase" which begins immediately following boost phase and lasts until apogee, technically is the initial part of the midcourse phase.

acceleration – interceptors are needed to achieve boost-phase intercept protection for all U.S. cities.

- The best coverage would probably be provided by two ships – one of which might have to operate "in harm's way" near the North Korean coast to gain boost-phase intercept opportunities for missiles launched at cities east of a line between Chicago and Miami. The other – based further away from North Korea – could protect all U.S. cities with ascent-phase intercepts, once the higher velocity interceptors are deployed.

These observations strongly suggest an acquisition strategy that continues block improvements to enhance the *Aegis* BMD system capability via faster and more capable SM-3 interceptors to enhance an already impressive operations capability.

Near-Term Counters to Off-Shore Ballistic Missile Threats

A second new role for *Aegis* BMD ships is to exploit their proven, tested capability against short-, medium- and intermediate-range ballistic missiles to protect against those that might be launched from nearby vessels off our East Coast. The *Aegis* BMD system's overall twenty-eight-out-of-thirty-four success record includes successful intercepts of target missiles in their ascent phase (first accomplished a decade ago by the Block IA). In a few years these interceptors will be replaced with the more capable IIA with its greater burnout velocity and larger footprint as discussed above.

Thus, the only issues for defending against vessels that launch ballistic missiles near our coasts is whether crews on our *Aegis* BMD ships normally operating in proximity of our coasts are trained and ready to do so. This proven ability of the SM-3 to destroy theater ballistic missiles (TBMs) can help to deter and defeat a HEMP attack, provided the *Aegis* ship is close enough to intercept the attacking ballistic missile before its nuclear weapon is detonated.

The ascent-phase intercept capability is illustrated in figure 7 against 600-km range TBMs that could be used to launch an EMP strike from off the U.S. East Coast. The orange-shaded section is the launch area of TBMs defended against by the U.S. *Aegis* ship shown in the green-shaded section. The green-shaded section represents the corridor traversed by missiles launched from

FIGURE 7

Aegis/SM-3 Notional Interception Footprint for Coastal Defense Against an EMP Attack

anywhere in the orange-shaded section that can be intercepted by the *Aegis* ship before they reach U.S. territory.

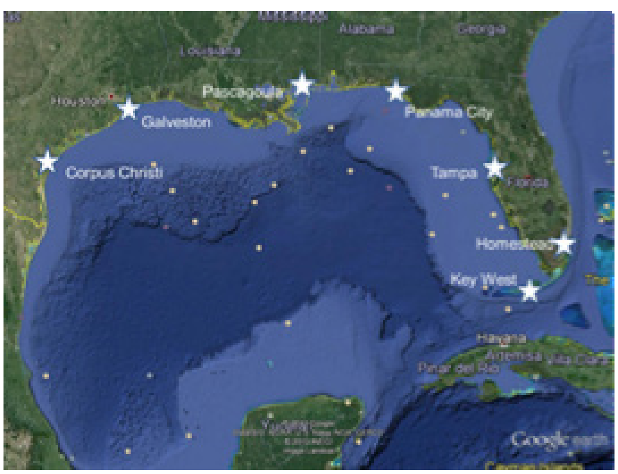
If the SM-3 interceptors on these *Aegis* BMD ships were periodically tested on the East Coast Test Range (supported by radar and other existing sensors located along the Eastern Seaboard), then those who would like to conduct an off-shore EMP attack might be deterred – and if not the *Aegis* BMD ships could defend against that attack. Such tests are regularly conducted by *Aegis* BMD ships operating near Hawaii. This capability, along with the ground-based interceptors in Alaska and California, can defend Hawaii and the West Coast against missiles launched from ships off the West Coast. Testing within the East Coast Test range would help provide comparable protection to those living on the East Coast.

FIGURE 8

Aegis Ashore sites, illustrated in figure 8, within appropriate military bases could fill any gaps in our normal deployment operations near our coast. Possible locations along the East Coast include Ft. Dix, New Jersey; Camp Lejeune, North Carolina; or Kings Bay, Georgia. Testing within the East Coast Test Range would also add deterrent value to these operations. There are numerous possible locations to fill in gaps on our West Coast not already covered by the West Coast GBI sites and *Aegis* BMD operating areas.

Such an *Aegis Ashore* site is now operational in Hawaii for testing the concepts planned for operational deployment in Romania (in 2015) and Poland (in 2018). An easy application would be to deploy an *Aegis Ashore* site near Moorestown, New Jersey where Lockheed Martin has long maintained a capability for full scale testing of all aspects of the *Aegis* command and control system. The entire system can fit into the area of a football field.

FIGURE 9



Our *Aegis* BMD ships can defend our east and west coasts. But that will leave a major gap in our defensive coverage against vessels that launch ballistic missiles from the Gulf of Mexico (or Latin America),[23] because our *Aegis* BMD ships seldom if ever operate in the Gulf. *Aegis Ashore* sites at several military bases around the Gulf could end that vulnerability.

Figure 9 gives several possible *Aegis Ashore* sites along the Gulf Coast. The number of required bases for full defensive coverage depends on the interceptor velocity, as discussed above. For the current (Block IA/B) system, 3-4 bases might be required. For the future Block IIA – or especially a follow-on block

23 Iran cooperates with Venezuela and possibly other states in Latin America. So do Russia and China. In June, 2013, Panamanian officials stopped a North Korean vessel during its attempted passage from Cuba through the Panama Canal and discovered two SA-2 rockets, capable of carrying nuclear warheads to create HEMP effects over a major portion of the United States.

improvement with a greater burnout velocity – this requirement might be reduced to perhaps two sites.

U.S. missile defense planning should deal comprehensively with the ballistic missile threats from off our coasts – and notably those from the south via the Gulf of Mexico or Latin America. Special priority should be given to blocking strategies that could produce HEMP effects that present an existential threat to all Americans.

These *Aegis Ashore* sites would require a 24/7 electrical power generating capability that is internal to the system. Obviously, this power plant should be hardened as a design requirement, and, under certain conditions, could be available for emergency response to lessen the impact of the loss of electricity-generating capabilities, thus reducing the vulnerability of disruption from a HEMP attack, beginning to mitigate its consequences, and increasing the deterrence value of the overall missile defense architecture against HEMP.

Near-Term Counters to the FOBS HEMP Threat

A third new role for our *Aegis* BMD ships is to counter the FOBS threat from the South, including an appropriate acquisition and operations plan. There are at least two ways: 1) operating in an antisatellite (ASAT) mode, and 2) being configured to be the nation's first operational boost-phase intercept system.

Exploit Inherent ASAT Operations. On 20 April, 2008, in Operation Burnt Frost, the *Aegis* BMD SM-3 Block IA interceptor shot down a dying satellite that threatened to spread toxic fuel on populated areas.[24] Thus, the currently deployed Block IA and IB systems have an inherent capability to shoot down low-orbit satellites, if appropriately located and cued with supporting information that permits the interceptor kill vehicle to get close enough to the target satellite to complete the intercept with its on-board sensor capability.

All that is required is training and assurance that the needed cuing information can be provided. The first condition is easily met, the second can be provided by appropriately forward-based radar sites. For example, deployment of a TPY-2 radar site in the Philippines could give *Aegis* BMD ships in the Pacific an ASAT capability against a North Korean FOBS. As SM-3 interceptor block improvements increase its burnout velocity, it will gain increasing capability against the FOBS threat from North Korea and Iran. The greater an interceptor's burnout velocity, the higher it can reach to intercept a threatening nuclear armed satellite.

Notably, a TPY-2 radar in the Philippines would also enable the ground based interceptors

24 The Burnt Frost documentary can be viewed by going to http://www.youtube.com/watch?v=pDqNjnUNUl8 .

at Vandenberg AFB in California against a FOBS attack. So, an inexpensive operational layered ASAT capability against a North Korean FOBS is readily available, provided the U.S. and Philippine administrations would approve siting a TPY-2 radar at an appropriate Philippine location.

Such an agreement might be worked out in conjunction with the Enhanced Defense Cooperation Agreement (EDCA), recently signed by Presidents Obama and Aquino.[25] Perhaps the United States might in the exchange agree to co-locate an *Aegis Ashore* site with the TPY-2 radar to provide the Philippines with an ABM capability.

An appropriate TPY-2 radar site south of the Iranian satellite launch sites could enable a similar ASAT capability against an Iranian FOBS attack. Such diplomatic initiatives should be undertaken immediately, possibly as part of recently reported and presumably ongoing discussions with allies in the region on joint defenses against a nuclear-armed Iran.[26]

Exploit Inherent Boost-Phase Intercept Operations. Although it is not generally appreciated, U.S. *Aegis* BMD ships already carry an operational endo-atmospheric interceptor that has an inherent boost-phase intercept capability if a host ship can maneuver close enough to the threatening FOBS launch sites. For the historical launch record of North Korean, and some Iranian, satellite launches from sites near international waters, this is clearly possible.

Thus, the U.S. Navy should modify the launch algorithms to give this capability to the *Aegis* SM-2-Block IV interceptor, which is three-for-three in its tests against ballistic missiles in the atmosphere moving at speeds consistent with the first stage burn time of North Korea's or Iran's satellite launches. The target for the intercept would be the upper stages of the launch booster – even the payload itself, which is far removed from the burning rockets that might otherwise blind the SM-2 interceptor's sensors. (If the nuclear payload were salvage fused, the intercept could set off the nuclear weapon over the North Koreans or Iranians – not a bad side benefit that itself might have deterrence value).

To be effective, this intercept action by the *Aegis* ship's captain must be pre-authorized by appropriate authorities, consistent with warning of a potential satellite launch, so as to assure the intercept can be carried out in a few tens of seconds after satellite launch. This requirement is shared by all potential boost-phase intercept systems.

To support this requirement, the United States should demand that all North Korean

25 See the April 28, 2014 White House press release at http://www.whitehouse.gov/the-press-of

26 See, for example, http://www.reuters.com/article/2014/04/27/usa-iran-gulfsecurity-idUSL6N0NJ08W20140427 .

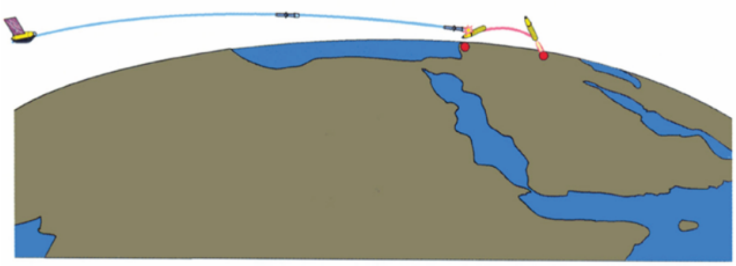
and Iranian satellite launch payloads be inspected by an appropriate body in which we have confidence – e.g., the International Atomic Energy Agency (IAEA). If not, it should be U.S. policy that we will shoot down such satellites so launched. This will enable the *Aegis* BMD ship's captain to execute a boost-phase intercept. This contingency plan should accompany a declaratory policy threatening immediate devastating retaliation should Iran or North Korea launch a FOBS attack.

Other Possible Responses. There are at least two additional possible defensive measures that should be considered even though they may take longer to develop than those above.

- Air-based interceptors that can reach the altitudes of concern should be considered. There have been many advances since 1985 when the F-15 fighter aircraft ASAT system was used to shoot down a satellite at about 350 miles altitude.[27] A problem is that an air-based interceptor must be on station to meet the required timelines, requiring more warning than is likely in most scenarios of concern.
- An on-station alert space-based interceptor system would be most effective, not only in shooting down a FOBS attack, but also in providing effective defenses against all ballistic missile attacks of more than a few hundred miles away – from anywhere to anywhere else. Such a system, *Brilliant Pebbles*,[28] was proving its mettle when the Clinton administration cancelled it in 1993 for political reasons. Today's technology would enable an even more capable system than what the first and third directors of the Strategic Defense Initiative (SDI) thought was the best technology developed for the $30 billion invested during the decade from 1983 to 1993.[29]

The possibilities for such a space-based defense are evident from figure 10, at a conceptually accurate scale, showing how a low-altitude orbiting defensive satellite might be directed to intercept even a short-range ballistic missile. Detailed computer simulations in the early 1990s showed that such a space-based defense could have shot down all of Iraq's SCUD missiles during the 1991 Gulf War long before they reached Tel Aviv or Haifa.

FIGURE 10



27 See http://en.wikipedia.org/wiki/ASM-135_ASAT .

28 *Brilliant Pebbles*, a space-based missile defense system designed in the early-1990s, consisted of 1,000 small satellites in low-Earth orbit, capable of destroying as many as 200 nuclear warheads. Weighing only 45 kilograms, each *Brilliant Pebble* platform would detect, track and intercept hostile missiles within its field of view. See *The Post-ABM Treaty Missile Defense and Space Relationship Report*, pp 26-31, which can be downloaded at http://www.ifpa.org/currentResearch/currentResearch.htm. For a history of this important program, see Donald R. Baucomb's "The Rise and Fall of Brilliant Pebbles," *The Journal of Social, Political and Economic Studies*, Volume, 29, No. 2, Summer 2004; or link to http://highfrontier.org/oldarchive/Archive/hf/The%20Rise%20and%20Fall%20of%20Brilliant%20Pebbles%20-Baucom.pdf

29 "The Dividends of SDI," by Amb. Henry F. Cooper and Lt. Gen. James A. Abramson, USAF (Ret.), *Journal of International Security Affairs*, Spring 2014. See http://highfrontier.org/wp-content/uploads/2013/06/The-Dividends-of-SDI.pdf .

Such intercept possibilities exist because of the high velocity of any object in low-earth orbit – faster than an ICBM which reaches much higher altitudes than the defense orbit. Longer range attacking ballistic missiles than depicted above would be simple targets for such a defense, provided the defense can discriminate the attacking missile/warhead from decoys.

Thus, defeating a HEMP attack like those discussed above would be relatively easy for such a space-based defense. Attempting high altitude detonations (and to reach longer distances) would require the attacking ballistic missiles to fly through the orbiting defense interceptors, presenting multiple easy shots for the defense.

An unpiloted air vehicle (UAV) component also could provide a capability to intercept nearby missiles in their boost- and ascent-phases. This technology is not new: the Strategic Defense Initiative in 1992 initiated technology development for a system concept called *Raptor-Talon*. (*Raptor* was the UAV and *Talon* was the airborne interceptor based on lightweight *Brilliant Pebbles* technology). Raptor-Talon could be revived and developed to support the coastal defense mission – or to defend against FOBS during its launch phase.[30]

Frequently lost in BMD discussion are the critically important sensor and C^3I key elements needed to guide interceptors to their targets. While waiting for preferred full-sensor capability and coverage from space-based assets, UAV-borne sensors could use demonstrated capability (e.g., in Afghanistan, Pakistan, and Iraq) to provide near term, scalable regional missile defense sensor solutions. UAVs can be on station in "orbits" off the U.S. coast to identify ballistic missile launch preparations and provide early warning of a ballistic missile launch. If armed, these same UAVs can intercept a missile launched from a ship in their boost- and ascent-phases.

The Navy is evaluating a carrier-borne UAV called the X-47B Navy Unmanned Combat Air System or NUCAS for intelligence, surveillance, and reconnaissance (ISR), command and control, and strike missions.[31] This UAV is large enough to carry missiles for boost- and ascent-phase interception. With the Airborne Laser (ABL) now facing a lengthening technology development phase because of the decision to reduce funding and slow the program down, together with cancellation of the kinetic energy interceptor (KEI), the NUCAS system is the only viable UAV missile

30 During the George H. W. Bush administration, SDI pressed for a UAV capable of boost-phase intercept. The *Raptor-Talon* program (developed by Lawrence Livermore National Laboratory (LLNL)) was approaching the testing stage in 1993. The idea was that UAVs would orbit on the edges of a battle area to detect launches of short-range tactical ballistic missiles and perform boost-phase intercept using extremely fast hypervelocity interceptor missiles. The Clinton administration transferred the program to NASA and drastically reduced its scope. A solar-powered version (which charged the batteries during the day and flew on battery power at night), also developed under LLNL management, was also transferred to NASA and has set high-altitude records.

31 The strike-fighter-sized NUCAS aircraft is envisioned as a sea-based, ultra-stealthy, force multiplier in high threat environments that will provide aircraft carriers with leap-ahead combat capability and survivability, particularly for ISR and long-range strike missions.

defense concept that might become operational over the next seven to eight years. Finally, NUCAS could be staged either from carriers or military airfields.

In sum, there are near-term opportunities to meet the EMP threat with an increasingly robust architecture. These include *Aegis* BMD based on the SM-3 and SM-2 interceptors (available now and possibly in increasing numbers, and with planned improvements on subsequent versions); *Aegis Ashore* (operational in 2015), and the NUCAS that could carry interceptors for boost- and ascent-phase (potentially available by 2018). The already-deployed SM-3 can begin to counter the EMP threat now; and the higher-velocity SM-3 improvements and increased numbers planned in the years ahead could make an EMP attack even less likely to succeed. These programs should be expanded to enable a boost-phase intercept capability.

Enhance U.S. EW/BM/C³I Capabilities

Effective defenses depend on timely, effective early warning, tracking and battle management and command, control, communications, and intelligence (EW/BM/C³I) capabilities. This is illustrated by the emphasis MDA is placing on deploying additional radar coverage.[32]

It is also illustrated by three important less positive examples that suggest important recommendations:

- The above discussed role that relatively inexpensive TYP-2 radars can play in giving a near-term operational homeland defense capability to the *Aegis* BMD ships that are always near our eastern seaboard and an ASAT capability for on-station *Aegis* BMD ships against potential North Korean and Iranian FOBS attacks,
- Actionable early warning required for an *Aegis* BMD ship captain to order the SM-2 Block IV to intercept a FOBS launch in its boost phase – within a few tens of seconds after the threatening satellite booster leaves its launch pad, and
- The February 13, 2013 FTM-20 test[33] in which the *Aegis* BMD system relied on the prototype Space Tracking and Surveillance System (STSS-D) experimental space-based sensor to detect, track, and enable the SM-3 Block IA interceptor to shoot down a medium-range ballistic missile (MRBM), proving the importance of space sensors which, if fully deployed, would

32 See the Testimony of MDA Director VADM James D. Syring before the House Armed Services, Subcommittee on Strategic Forces, March 25, 2014, http://docs.house.gov/meetings/AS/AS29/20140325/101945/HHRG-113-AS29-Wstate-SyringUSNavyJ-20140325.pdf.

33 The FTM-20 test near Hawaii demonstrated the *Aegis* BMD system's "launch on remote" capability to launch its interceptor long before the target ballistic missile is picked up by the on board SPY-1 radar. For more details, see www.defense.gov/news/newsarticle.aspx?id=119281 and at www.youtube.com/watch?v=0Um1rKUrXVc.

provide an important global capability.[34] After this important test proved that space sensors are a key part of the needed global BMD architecture, the program intended to provide that capability was terminated due to lack of funds.

While not criticizing the importance of MDA's current efforts to build and deploy radar capabilities abroad, we believe these examples illustrate key continuing shortcomings – in some cases attributed to management inattention over many years (at least a decade) and in others to a lack of funding, given the current overall constraints Congress has placed on the defense budget. All should be funded and executed to advance to an operational status as soon as possible. In particular, a space-based sensor system would provide needed worldwide support to all our missile defense systems, including our *Aegis* BMD ships wherever they are stationed.

Early warning of a pending attack also could empower the U.S. Navy (and our allies and friends) with an ability to identify, tag, track and interdict a vessel carrying nuclear-armed short- and medium-range ballistic missiles capable of delivering an EMP attack on the United States before it approaches U.S. territorial waters. Accomplishing this objective is closely aligned with an Obama Administration top priority, which in turn can be associated with the Proliferation Security Initiative and the Global Initiative to Combat Nuclear Terrorism – international operations that involve many nations. Meeting this challenge should be integrated with the on-going development of the objectives and capabilities associated with the National Plan to Achieve Maritime Domain Awareness[35] – and they in turn should be integrated with the missile defense command and control architecture to defeat a HEMP attack on the United States. These operations are, in fact, the first line of defense in the layered defense against HEMP attacks on the United States from off U.S. coasts.

If such operations are unsuccessful and ships carrying HEMP-threatening missiles approach our shores, then confidence in a well ordered command and control system is crucially important to enable an effective missile defense system to defeat that time urgent threat. Real-time information and pre-delegated authorization are needed by the on-the-scene commander who must launch the interceptor in time to destroy the threatening missile in its early stage of flight – in some cases, within a few tens of seconds after its launch.

34 For a description of the since canceled SSTS-D program, see http://www.mda.mil/global/documents/pdf/stss.pdf.

35 The National Plan to Achieve Maritime Domain Awareness (NPAMDA) is one of the supporting implementation plans that grew out of the December 2004 National Security Presidential Directive-41/Homeland Security Presidential Directive-13 on *Maritime Security Policy*. The goal of NPAMDA is to identify maritime threats as early and as distant from U.S. shores as possible by providing accurate information, intelligence, surveillance, and reconnaissance of all vessels, cargo, and people extending well beyond our traditional maritime boundaries. See the *National Plan to Achieve Maritime Domain Awareness for The National Strategy for Maritime Security*, October 2005 at http://www.dhs.gov/files/programs/editorial_0753.shtm.

The concept-of-operations must define the conditions for delegating authorization to the on-the-scene commander to enable interception early in the flight of the ballistic missile. There is not time for the chain-of-command to gain a common understanding of the tactical situation and consult on the "missile defense launch order." If this threat materializes, the launch authority must be "pre-delegated." Everyone can watch, but the launch authority must be given to the on-the-scene commander, i.e., the captain of the *Aegis* ship that has the intercept opportunity.

The U.S. Navy has devoted great effort to providing to all appropriate command levels the necessary real-time information with its Cooperative Engagement Capability (CEC) as the key enabler for the detection, tracking, and identification of air targets.[36] The above stated need for prior authorization to launch anti-EMP interceptors implies that many previously conceived battle management/command, control and communications operations assumptions must be re-evaluated. This new requirement for pre-delegated launch authorization for anti-EMP interceptors is not inconsistent with those that must also flow from the new emphasis on achieving theater/regional defense and ascent-phase engagements.[37]

Thus, no longer are decision times measured in tens of minutes – the timelines are now much shorter – a few tens of seconds in the case of launching an effective boost-phase interceptor. Reliable, uninterrupted data from sensors and commanders must be available to the on-the-scene commander much sooner – in near-real time. The many nodes and burdensome overhead in current command and control concepts that would delay information and cause confusion must be streamlined. Simulations that include HEMP scenarios could elaborate response requirements and needed corresponding command capabilities.

36 CEC is a sensor netting system that allows many ships to pool their radar and sensor information together, creating a more detailed picture than any one ship could generate on its own. The data is then shared among all ships and participating systems at sea, in the air, and on the ground, using secure frequencies.

37 In 2009, U.S. defense officials announced an increased focus on developing technologies for ascent-phase intercept (API) to hedge against the growing threat and to realize the greatest potential for reducing cost and increasing the operational effectiveness of missile defense. This decision was based in part on a Defense Science Board 2002 Summer Study, which underscored the advantages of ascent-phase intercepts and that they are significantly less challenging than boost-phase interception. Among other benefits, APIs allow interdiction before countermeasures are deployed, minimize the potential impact of debris, and reduce the number of interceptors required to defeat threat missiles in the later stages of a threat missile's flight. See Defense News. "MDA Request Kills KEI, Focuses on Ascent Phase, May 7, 2009: http://www.defensenews.com/story.php?i=4079560

Summary, Conclusions and Recommendations

HEMP effects could have devastating and possibly permanently crippling effects on our society, economy, and national security. The United States must, as soon as possible, develop a comprehensive strategy to provide an increasingly robust defense to deter or defeat HEMP attacks.

Beyond strengthening our current defenses, we should seek to prevent threatening vessels from approaching U.S. territorial waters (especially in the Gulf of Mexico) close enough to launch a ballistic missile to create an HEMP event – and failing that, to intercept the missile in its ascent phase before it releases a nuclear warhead. We need defenses around the Gulf of Mexico to defend against this threat from the Gulf or Latin America. We also need to intercept ICBMs that approach the United States from the north or FOBS weapons that approach from the south.

No defense is perfect. Therefore, we also need to harden our critical infrastructure against the possibility that our defenses fail and we are confronted with a successful HEMP attack. Such a strategy should give priority to assuring the survival of the electric power grid, upon which essentially all other critical infrastructure depends, including the operation of most military systems. This conclusion repeats the finding of the EMP Commission reports of 2004 and 2008.

If a strategy is developed to assure that the electric power grid can continue to operate through – or can quickly be revived after – an HEMP attack, it will also be viable in case of natural EMP threats – e.g., from solar storms that present a threatening CME/GMD. The converse is not true; therefore, priority should be given to assuring the grid is viable in the face of a HEMP attack.

Effective defenses are needed to persuade potential attackers that we can defeat a HEMP attack and retaliate should they attempt one. Our proposed architecture supplements the current ground-based defenses in Alaska and California with several components – *Aegis* BMD ships, *Aegis Ashore* sites, R&D on pertinent air- and space-based capabilities, and enhanced early warning and communications, command, control, and intelligence systems. The following possibilities should be considered:

- Defensive interceptors on *Aegis* BMD ships normally operating off U.S. shores can provide a proven ability to intercept short-, medium- and intermediate-range ballistic missiles in their ascent and midcourse phases. With cueing from a relatively inexpensive TYP-2 radar in New England, *Aegis* BMD ships along the eastern seaboard can defend against Iranian ICBMs.

- Such a sea-based capability can be supplemented with ground-based SM-3, *Aegis Ashore* sites as a reinforcing layer at various coastal military bases – and as the main defense against an HEMP attack from the Gulf of Mexico or Latin America, while providing some defense against a FOBS attack from the south. (*Aegis Ashore* sites would have the added advantage of requiring an electrical power generating capability hardened against HEMP and therefore could be available for emergency civil response.)
- Currently operating *Aegis* BMD ships can quickly be given an ability to counter FOBS attacks from North Korea and Iran by two inexpensive initiatives: 1) deploy appropriately placed TPY-2 radars to cue the inherent *Aegis* ASAT capability – e.g., in the Philippines to counter North Korea and in a yet to be determined location to counter Iran; and 2) on warning, move *Aegis* BMD ships in position to shoot down, in their boost-phase, rockets launching satellites unless their payloads are confirmed not be nuclear weapons.

High priority command and control initiatives include improving maritime awareness to identify and prevent suspicious vessels from getting close enough to the U.S. coast to launch a HEMP attack. Failing that, an effective intercept in the face of the very short warning time requires prior authorization for the on-the-scene commander to launch anti-HEMP interceptors. Critical cuing data must be available in seconds, not tens of minutes. In light of HEMP timelines, battle management and command, control, and communications must be reassessed and improved.

In our opinion, *Aegis* SM-3 IB and IIA deployment schedules should be accelerated as much as possible, and the critically important EW/BM/C^{3}I capability should be upgraded to enable our current interceptor capabilities – including the immediate deployment of a TPY-2 radar in New England to enable *Aegis* BMD ships along our eastern seaboard to defend against Iranian ICBMs – and as quickly as possible deploying TPY-2 radars to enable an ASAT capability against FOBS attacks from North Korea or Iran. Next, we should accelerate the current plans to acquire additional SM-3 Block IB interceptors for our ships at sea and next year's *Aegis Ashore* operations in Romania and to accelerate development of the Block

IIA, now scheduled for 2018 deployment in Poland. Given defense budget constraints, we should first guard against slippage in these deployment schedules.

Beyond these top priority recommendations, we recommend that MDA include innovative future improvements to our current global BMD architecture, including:

- A UAV component to strengthen boost- and ascent-phase interception of short-, medium-, and intermediate-range missiles, especially near U.S. coasts. UAV-borne sensors and missiles could be stationed off U.S. shores to detect ballistic missile launch preparations and a missile's infrared signature if launched, as well as to intercept it.
- Revival of viable space-based defense programs, especially to deploy a space-based sensor system to cue U.S. terrestrially based BMD systems. R&D on space-based interceptors also should be initiated, especially to defend against a FOBS attack from Iran or North Korea that could overfly U.S. surface based interceptors.

While missile defense forms an indispensable pillar of a strategy against the HEMP threat, it must be acknowledged that no defense is perfect; therefore, efforts are needed to assure that at least the electric power grid can survive or easily be reinstated after a HEMP attack. Finally, it should be noted that if this defense is mounted, then the electric power grid will also be viable in the face of massive solar storms, which will one day occur.

The building blocks for this architecture are available. What is required is the implementation of a strategy, such as set forth in this White Paper, to pull them together in timely near-term fashion.

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