



National Security Update

The 2018 NDAA, the Ballistic Missile Defense Review, and the New EMP Commission

This *IFPA National Security Update* provides information on missile defense issues related to the 2018 National Defense Authorization Act (NDAA) and the soon-to-be-released Ballistic Missile Defense Review (BMDR). It also provides an update on several developments regarding electromagnetic pulse (EMP), including Congress' decision to create a new EMP Commission. Key conclusions and recommendations include:

1. Ballistic Missile Defenses

- Develop the near-term boost-phase-intercept options as recommended in the NDAA; the BMDR should adopt these recommendations;
- Likewise, the BMDR should adopt the NDAA's recommendations to proceed with a space-based missile defense sensor layer and a space intercept layer; and,
- Develop a revised *Brilliant Pebbles* program, a space-based missile defense system under development in the early-1990s during the Strategic Defense Initiative, incorporating more recent technological advances as a path to a cost-effective space-intercept defense.

2. Electromagnetic Pulse

- Select individuals for the New EMP Commission who understand the severity of the man-made and naturally occurring EMP threat and how missile defenses and hardening the U.S. infrastructure, particularly the U.S. power grid, can address it;
- Continue public-private "bottom-up" partnerships at the local and state levels to harden power grids against EMP effects; and
- Pass the long-stalled Shield Act in Congress which directs U.S. electric-power companies to safeguard the national grid from EMP.

The 2018 NDAA and the Ballistic Missile Defense Review

The passage of the final Fiscal Year (FY) 2018 National Defense Authorization Act by Congress in mid-November 2017 directs the Department of Defense (DOD) to pursue the following:

- The Standard Missile (SM)-3 IIA with a capability to intercept ICBMs;

- A near-term boost-phase intercept (BPI) capability;
- A space-based sensor layer for missile defense;
- A space-based intercept layer; and,
- A space test-bed.

In addition, it is expected that DOD's Ballistic Missile Defense Review (BMDR) will also pursue a number of the NDAA recommendations (more below).

The urgency of proceeding with these recommendations has assumed greater importance because of North Korea's rapidly improving nuclear and ballistic missile programs. The successful launch of two missiles in July 2017 demonstrated that North Korea has almost certainly developed the capability to strike Alaska and western portions of the United States with an intercontinental ballistic missile. On November 29, 2017, Pyongyang tested a new missile signifying that if flown on a trajectory designed to maximize its range this ICBM likely could have hit targets throughout the U.S. mainland, including Washington, D.C.ⁱ

This accelerating ICBM capability is made even more dire by the fact that analysts at the Defense Intelligence Agency now believe North Korea can miniaturize nuclear warheads to fit on its ballistic missiles.ⁱⁱ The North Korean threat, which includes a capability for an electromagnetic pulse attack, is evolving far more quickly than previously presumed by the intelligence community and consequently specific steps, such as those outlined in the 2018 NDAA, should be taken to address this growing peril.

The 2017 NDAA passed by Congress in December 2016 directed the Secretary of Defense and the Chairman of the Joint Chiefs of Staff to conduct a review – sometimes referred to as the Missile Defeat Review or MDR – of the U.S. missile defense strategy and objectives and to provide a comprehensive assessment of present capabilities and future missile defense requirements. The current review differs from the 2010 Missile Defense Review in that it directs DOD to examine left-of-launch missile defense options, including cyber and pre-emption, and the range of right-of-launch measures to include defense against cruise missiles, boost-glide vehicles, and unmanned aerial systems. DOD is to evaluate the available means to meet missile defense requirements, including technological developments, budgetary resources, acquisition requirements, and organizational relationships, and other policy considerations.

Shortly after assuming office, President Trump directed Secretary of Defense James Mattis to undertake an assessment of U.S. ballistic missile defense policy and requirements. A key goal of this assessment is to strike a more equitable balance between homeland and regional defense, putting greater emphasis on the former. The White House-directed assessment has been folded into the Congressionally-mandated MDR described above. The combined studies, now referred to as the BMDR, will provide details on the Trump Administration's missile defense goals, direction, and system priorities.

It is expected that key BMDR recommendations will include the development of a space-based sensor layer, a space test bed, armed unmanned aerial vehicles or UAVs (also referred to as

remotely piloted aircraft or RPAs – see the next section) for boost-phase intercept, and additional missile defense research and development (R&D).

Congress' directives in the 2018 NDAA's to develop a near-term BPI capability, a space sensor and intercept layer, and a space testbed are each preceded by a phrase that may determine their ultimate fate: "*If consistent with the direction or recommendations of the Ballistic Missile Defense Review, ...*" Without the imprimatur of the BMDR, therefore, these programs may not proceed.

However, there should still be ample opportunity to shape missile defense policy – and therefore programmatic priorities – following the release of the BMDR as its implementation phase begins. The BMDR is expected to be sent to the White House for review in mid- to late-December with a public roll-out anticipated in mid- to late-January 2018.

The 2018 NDAA also directs the Pentagon to explore development of a possible East Coast missile defense site equipped with ground-based interceptors (GBIs). However, if the Standard Missile-3 IIA proves capable of ICBM interception (which the NDAA directs DOD to ascertain),ⁱⁱⁱ a less costly and far quicker deployment approach for an East Coast site may be to field an *Aegis Ashore* battery (or batteries) outfitted with SM-3 IIAs.

As part of the BMDR's recommendations, it has already been announced that there will be over \$4 billion in additional funds for missile defense programs in the 2018 NDAA, primarily for procurement. The increase is intended to help make up for the dramatic shortfalls in missile-defense procurement accounts over the past several years. It includes funds for additional GBIs, Standard Missile-3 IIAs, THAAD, and *Patriots*. This FY18 plus-up follows the reprogramming in September 2017 of approximately \$250 million in FY17 funding to the Missile Defense Agency (MDA). If these funds are appropriated by Congress, FY18 spending for missile-defense efforts may top \$11 billion.

Although President Trump signed the 2018 NDAA bill on December 12, 2018 authorizing almost \$700 billion in defense spending, this figure exceeds the 2018 budget spending cap of \$549 billion established in the 2011 Budget Control Act (BCA) by approximately \$150 billion. Consequently, for the ~\$700 billion NDAA funding level – and likely the missile defense plus-up – to take effect, Congress must alter BCA spending limits.

Boost Phase Intercept and Cost Estimates for Space-based BPI

Achieving a boost-phase intercept capability would significantly augment the effectiveness of any missile defense architecture. BPI allows a series of highly desirable outcomes: relative ease of interdiction because the ballistic missile is moving slowly and producing an enormous infrared signature facilitating detection and targeting; the missile has not released its warheads/decoys; all or most of the debris from the intercepted missile would fall back on the territory of the launching nation; and it would lessen the defense burden on U.S. midcourse- and terminal-missile defense systems. In addition, BPI would reverse the offense-defense cost-exchange ratio that currently favors the offense.

Near-term BPI options which should be pursued as part of the 2018 NDAA recommendations include a concept based on a remotely piloted aircraft (RPA) armed with conventional missiles designed to intercept a ballistic missile before it leaves North Korean airspace. The high-

altitude, long-endurance RPA would patrol over the Sea of Japan, approximately 60 miles off the North Korean coast in international airspace for up to 20 hours at an altitude of 12.2 kilometers providing sufficient observation of potential North Korean ballistic missile launches. The two candidate RPAs, both produced by General Atomics, are the Predator B and the Avenger.

Launch detection, tracking, and battle management/command, control, and computing (BMC3) would be provided by the system currently on the F-35 aircraft. The two-stage intercept missile would reach speeds of 3.5 kilometers per second. A decision to engage the threat missile would be made by “man-in-the-loop” with an approximately 66-second window to destroy the threat missile.

The RPA BPI concept would employ the same pilots and personnel already in place for current air-to-air and ISR (intelligence, surveillance, and reconnaissance) RPA operations and utilize existing systems/technologies previously tested and confirmed to be operational. This would result in significant cost savings. With appropriate funding and resources, this BPI concept could be demonstrated within a year with initial deployments to follow soon afterwards.

Another near-term BPI option is the F-35 aircraft outfitted with the advanced medium-range air-to-air missile (AMRAAM) to interdict North Korean ballistic missiles.^{iv} As noted above, the F-35 is equipped with a sensor suite and BMC3 kit capable of detecting and engaging ballistic missiles. The F-35 BPI concept has the strong support of Representative Duncan Hunter (R-CA), a member of the HASC Subcommittee on Strategic Forces which is responsible for oversight of missile defense.

A third possibility is the *Aegis*/Standard Missile-3 which should be pursued as part of the 2018 NDAA recommendations on near-term BPI options. If such an *Aegis*/Standard Missile-3 capability is confirmed, *Aegis* ships patrolling in the Sea of Japan would be able to conduct boost-phase intercepts of North Korean ballistic missiles.

A key step to optimize the effectiveness of these BPI concepts is to establish a no-launch zone over North Korea with the United States declaring that all ballistic missile launches from North Korean soil will be regarded as an immediate threat to the United States, its troops, and/or its allies and thus subject to interdiction while still in North Korean airspace.

The no-launch zone should also require inspections of North Korean satellites prior to launch to ensure they do not house nuclear weapons. North Korea currently has two satellites in orbit which were launched on a southern trajectory over the South Pole where U.S. sensor/radar coverage is less robust. If these satellites – or future ones – were outfitted with nuclear weapons they could deliver an EMP attack when orbiting over the United States. If Pyongyang did not permit the satellite inspections, the launch would be shot down.

Such authority would permit RPA/F-35 pilots and the Commander of an *Aegis* ship to initiate engagement immediately after a launch is detected and validated. Without such a concept-of-operations, valuable time would be wasted in shoot/no-shoot deliberations between command-authority decision makers and RPA/F-35 pilots/*Aegis* Commanders.

The Missile Defense Agency is currently exploring General Atomics RPAs for BPI but utilizing directed energy weapons (DEW) as the kill mechanism – as opposed to a kinetic energy weapon (KEW) as described in the concepts above. However, DEWs, particularly a system small enough to fit on a RPA, are years away from actual deployment.

As noted, if DOD/MDA pursued the RPA/KEW approach, a BPI capability could be fielded within two years or less. A similar fielding timeline is also likely the case for the F-35/AMRAAM concept. The timeframe for validating and testing the *Aegis*/Standard Missile-3 for BPI could also be two years, possibly less.

Certain classified cost estimates for a space-based intercept layer – which represents the optimal approach to achieve effective boost-phase interception – reportedly depict its price tag to be “prohibitive.” However, such cost projections are overinflated and fail to account for the growing availability and use of low-cost, commercial off-the-shelf products, components, and technologies together with advances in miniaturization and the plummeting costs for space launch and on-orbit sustainment and operations extant today.

In addition, the cost estimates in question did not examine the 1990s *Brilliant Pebbles* (BP) program as a path to a cost-effective space-intercept defense. For example, the estimated cost for *Brilliant Pebbles* was \$11 billion in 1989 dollars, or \$21.7 billion in 2017 dollars^v spread over a twenty-year life-cycle. The cost in 2017 dollars for the elements of the 1989 BP program is:

- \$14.33 billion for research, development, test, and evaluation;
- \$1.65 billion for production of 2000 BPs (or \$829,000 per BP) based on replacing each of the 1000 BPs once during the system’s 20-year life cycle;
- \$1.55 billion for launching 2000 BPs; and,
- \$3.90 billion for the 20-year operating cost.

The \$21.7 billion BP price tag could be even less because of technological advances realized in the commercial and defense sectors since BP was originally envisioned and priced and which would provide markedly greater intercept capabilities today.

General John Hyten, Commander, U.S. Strategic Command and the former Commander, U.S. Space Command, has stated that the United States needs to develop and deploy space systems far more rapidly, at reduced costs, and incorporate commercial best practices, an approach that would be required if a space-intercept layer is to be realized. Hyten has also stated that the Missile Defense Agency needs to change its culture to accept failure in its testing regimes. More realistic testing, which will include failures, will result in more robust, effective missile defense systems. Hyten’s comments also argue for moving forward with a space test bed as called for in the latest NDAA.

Russian and Chinese Use of “Lawfare” to Restrict U.S. Space Efforts

With the United States moving closer to missile defense in space, i.e., a space-sensor layer and possibly an intercept layer and space test bed, Russia and China will likely increase their efforts to gain support at the United Nations for the enactment of laws banning weapons in space. However, space has been weaponized since the first nuclear-tipped ballistic missiles

were deployed given that they would pass through space on route to their targets and that several nations possess this capability including Russia and China, the key proponents of banning space weapons.

These two nations are practicing “lawfare,” attempting to restrict U.S. ballistic missile, anti-satellite, and other space activities, even though both Moscow and Beijing are developing a range of ASAT capabilities and have tested them in recent years. For example, a 2007 direct-ascent ASAT test conducted by China resulted in the destruction of one its satellites in low-earth orbit producing thousands of pieces of debris; more recently China demonstrated a direct-ascent ASAT capability at a much higher orbit which could put in jeopardy key U.S. early warning and other critical national security space platforms. In addition, Russia has tested maneuvering satellites steering them into proximity of Intelsat communication satellites in geostationary orbit, an inherent ASAT capability.

The disingenuous Russian and Chinese calls for treaties to ban ASATs and space weapons are public-relation ploys and unverifiable. If the United States acceded to such accords it would be hand-cuffing itself while giving Russia, China, and other adversaries a free hand to test and surreptitiously deploy such capabilities. Their “lawfare” strategy is simply an attempt to hobble the U.S. space and missile defense programs.

If the United States determined that an adversary had carried out an ASAT or cyber attack on our space assets, the United States would need to respond with any means appropriate including with measures enacted in a different domain. For example, the U.S. response to an ASAT attack could include actions in the land, sea, air, and/or cyber domains and incorporate military, political, and/or economic measures. The United States needs to develop “levels of responses” in such circumstances, broader options between doing nothing and outright conflict that “creates pushback.”

One possible response to ASAT testing/cyber incursions by Russia and China would be to freeze current – and not grant future – visas for their citizens studying in the United States, especially those enrolled in or applying to science, technology, engineering and mathematics (STEM) studies in graduate programs. Particular attention should be paid to restricting students interested in aerospace disciplines which have direct application to space-based activities and capabilities.

The New EMP Commission

The current EMP Commission is being disbanded. This is a result of language in the House version of the 2018 NDAA calling for the establishment of a new EMP Commission which was later passed in the final NDAA. This is disturbing because setting up the new Commission will result in a needless waste of time and effort, particularly when the North Korean nuclear, ballistic missile, and EMP threat is becoming more acute. In addition, there is considerable concern that the expertise resident in the current EMP Commissioners will be lost while the new Commission may, because of politics and a tendency to ignore the severity of the EMP issue, become populated by individuals with little knowledge of EMP and understanding of what is needed to address the problem.

Twelve members for the new EMP Commission will be chosen by the House and Senate Armed Services Committees: three members will be appointed by the Chairman of the HASC and three by the HASC ranking minority member with the SASC following the same selection procedure. The Chairmen of the HASC and SASC will jointly designate one of the twelve selectees as Commission Chairman while the HASC/SASC ranking minority members will together choose the Vice Chairman. In addition, the 2018 NDAA stipulates that the new Commission “shall terminate on October 1, 2019,” less than two years from now.

The move to disband the EMP Commission emerged in part because of a fractured relationship between the EMP Commission and certain offices within the Pentagon which led to the involvement of Congress and eventually the successful effort to include a provision in the HASC version of the 2018 NDAA to dissolve the current EMP Commission which, as noted, was accepted in the final 2018 NDAA.

This unfortunate situation has certainly damaged the image of the EMP Commission within some segments of the executive branch and Congress. Steps should be taken to correct the inappropriately tarnished view of the current EMP Commission and to highlight its seminal work on the EMP threat.

The Task Force on National and Homeland Security,^{vi} an official Congressional Advisory Board dedicated to protecting the United States from EMP, cyber attack, mass destruction terrorism, and other threats to civilian critical infrastructures, will still be in place as the new Commission is being formed.

EMP Commission Reports

The current EMP Commission has produced twelve reports in a six-month effort. However, these reports have yet to be made public because they first need to be vetted by DOD authorities prior to release. One of the reports states that EMP is an element of a new way of warfare and that Iran is modeling Russian military doctrine including approaches to disrupt an enemy’s electric grid with EMP and cyber attacks.

These reports also reference an Iranian document entitled *Passive Defense* which details Tehran’s doctrine on EMP, hybrid warfare, and other military and strategic security policies. The document contains a section on the successful efforts of the Soviet Union to deceive the United States during their many bi-lateral arms control negotiations.

This Soviet program of arms-control deception undoubtedly served as a primer for Iran in its negotiations with the United States, the United Kingdom, Russia, France, China, Germany, and the European Union leading to the Joint Comprehensive Plan of Action (JCPOA) or more frequently known as the Iran Nuclear Deal.

It is important to make the *Passive Defense* document available (or at least its content and details) to government officials and the broader policy community to provide a better understanding of Iran’s military/national security goals and objectives, its approaches to achieving them, and the possible ramifications for the United States. Likewise, the results of the EMP Commission reports should be released as soon as possible so their findings can also be made available.

Perceptions of the EMP Threat and Flawed Studies

The EMP issue is an ideological struggle between elements of the left and some elements on the right. The left does not give credibility to the EMP threat largely because of the belief that EMP is simply a vehicle, a rationale to move the United States toward greater missile defenses in space, particularly space-based interceptors; while some on the right minimize the EMP threat because they do not understand EMP and its devastating effects.

Several EMP studies have arrived at spurious findings. One, the 2017 Report by the Electric Power Research Institute (EPRI),^{vii} concluded that only a limited number of bulk-power electric transformers would be at risk of damage following an electromagnetic-pulse attack. The conclusion that few transformers would be impacted resulted because EPRI used calculations for nuclear field strengths significantly lower than would actually be generated in the EMP-attack scenarios examined.

The EPRI Report also underestimated the field strength of a natural EMP occurrence. There is a 12.3% chance every decade of a Carrington-like event,^{viii} i.e., a massive solar storm, taking place. The U.S. government estimates such an event would cause \$2 trillion in damage in the first year alone with recovery lasting 4 to 10 years.^{ix}

As with the EPRI Report, the main reason EMP studies produce flawed findings is because incorrect (significantly too low) field strengths are utilized in calculating the effects of EMP attacks and consequently the destructive impacts of an EMP event are significantly underestimated. At times, this is because of bias, other times because the studies were conducted without access to classified data on EMP effects, and sometimes due to a combination of both factors.

For example, some government agencies/departments want to ignore and/or discount the EMP issue. In many cases, the results of classified EMP studies undertaken by DOD are not made available so subsequent studies by other government agencies or non-government institutions are conducted with inaccurate data, particularly regarding nuclear field strengths. Not being able to share classified data also hampers electric power companies and other critical infrastructure companies from understanding the EMP threat and the need to harden systems.

Hardening the Grid: Success Working from the Bottom Up and Passage of the SHIELD Act

Several bottom-up successes involving a public-private partnership with local, county, and state governments and power companies to protect and restore the electric power infrastructure in the case of an EMP or cyber event have been achieved.

This includes efforts in North and South Carolina in conjunction with Duke Energy, the nation's largest electric power company, engaging local citizens and officials to assure that, in the case of a major grid blackout, local electricity would be restored to areas surrounding Lake Wylie and other nearby areas, particularly around nuclear power plants. This North/South Carolina model is being expanded to Texas to protect the entire Texas Interconnection, the power grid that covers most of the state of Texas.

In addition, Louisiana is attempting to prepare for EMP events utilizing the Critical Infrastructure Protection Act (CIPA)^{xx} as the catalyst for this effort. Louisiana officials were working with then-DHS Secretary John Kelly (and now White House Chief of Staff) to reduce the consequences of EMP. CIPA directs DHS to collaborate with other executive agencies, state and local governments, and critical infrastructure owners/operators to address the EMP threat. It also instructs DHS to establish new national planning scenarios focused on protecting and recovering the nation from an EMP catastrophe, a key provision because all federal, state, and local emergency planning, training, and resource allocations are based on DHS national planning scenarios.

Such bottom-up efforts with local and state governments and power companies to harden our critical electric power infrastructure should continue, and where possible, be expanded.

Passage of the Secure High-Voltage Infrastructure for Electricity from Lethal Damage Act, better known as the SHIELD Act, by the U.S. Congress would go a long way to ensuring a protected and resilient national power grid. It would require U.S. electric power companies to harden the national grid and electric transformers against the range of EMP effects. The SHIELD Act remains stalled in Congress, in part because of the lobbying efforts and opposition of the electric power utilities.

Conclusions and Recommendations

- The BMDR should adopt the NDAA's missile defense recommendations particularly development of near-term BPI options, a space-based sensor and intercept layer, together with a space test bed, and validating the Standard Missile-3 IIA capability to intercept ICBMs. If the Pentagon fails to move forward with these efforts, particularly the space-based intercept layer, Congress may not soon get a second chance to enact such language in future NDAA's, particularly if the Democrats, who do not support a space-intercept layer, win back a majority in either the House or Senate in 2018.
- Apart from the RPA/KEW and F-35/AMRAAM concepts described earlier, the Missile Defense Agency and the Navy should validate the capability of the *Aegis*/Standard Missile-3 to conduct boost-phase intercepts.
- The United States should institute a no-launch zone over North Korea declaring that all its ballistic missile launches will be subject to interdiction. The no-launch zone requirement would also stipulate that North Korean satellites must be inspected before launch to guarantee they are not carrying nuclear weapons; no inspection, they are shot down.
- If the SM-3 IIA is confirmed capable of ICBM interdiction, MDA should explore the cost and procurement-time advantages of *Aegis* Ashore/SM-3 IIs as an option for the East Coast missile defense site vice a new site comparable to the current GBIs-in-silos deployments in Alaska and California which would be more expensive and require a lengthier deployment timeline than the *Aegis* Ashore option.
- For a space-based intercept layer, the United States should revise the *Brilliant Pebbles* program and its proven technologies produced during the Strategic Defense Initiative

incorporating the many technological and system advances made in both the defense and commercial sectors since then.

- The HASC and the SASC should select individuals for the new EMP Commission with proven expertise in EMP issues and solutions.
- The latest 12 EMP Commission reports, which are still being vetted by DOD officials, should be made public as soon as possible. In addition, the contents of the Iranian *Passive Defense* document, mentioned in the EMP Commission reports, should be made known to government officials and the broader policy community to provide a better understanding of Iran’s military/national security goals and objectives, its approaches to achieving them, and the possible ramifications for the United States.
- “Bottom-up” approaches with local and state governments and power companies to harden our critical electric power infrastructure should continue, and where possible, be expanded.
- Congress should enact as soon as possible the SHIELD Act to require U.S. electric power companies to harden the national grid against EMP effects.

Endnotes

ⁱ “North Korea’s latest missile launch appears to put U.S. capital in range,” by Anna Fifield, *The Washington Post*, November 29, 2017. See https://www.washingtonpost.com/world/north-korea-fires-missile-for-the-first-time-in-more-than-two-months/2017/11/28/0c136952-d46c-11e7-9461-ba77d604373d_story.html?utm_term=.9548865efbc9.

ⁱⁱ “North Korea now making missile-ready nuclear weapons, U.S. analysts say,” by Joby Warrick, Ellen Nakashima and Anna Fifield, *The Washington Post*, August 8, 2017. See https://www.washingtonpost.com/world/national-security/north-korea-now-making-missile-ready-nuclear-weapons-us-analysts-say/2017/08/08/e14b882a-7b6b-11e7-9d08-b79f191668ed_story.html?utm_term=.40adac165de3.

ⁱⁱⁱ A far less capable version of the SM-3 IIA has already demonstrated a capability to intercept ICBMs. In February 2008, a Navy *Aegis* ship using an early version of the SM-3 interceptor shot down an inoperable U.S. spy satellite before it could crash to Earth. The satellite was moving at more than 17,000 mph (comparable to ICBM speeds) when it was destroyed by the SM-3.

^{iv} On December 3, 2007 in a test at White Sands Missile Range in New Mexico, a F-16 aircraft shot down a sounding rocket in its boost phase with a modified AIM-9X air-to-air missile indicating that the more advanced F-35 and AMRAM would have a BPI capability.

^v The Bureau of Labor Statistics Consumer Price Index (CPI) Calculator was used for all 2017 cost figures.

^{vi} As a Virginia-based nonprofit organization, the Task Force is also referred to as the EMP Task Force on National and Homeland Security. It receives no Congressional funding, relying solely on donations.

^{vii} *Magnetohydrodynamic Electromagnetic Pulse Assessment of the Continental U.S. Electric Grid: Geomagnetically Induced Current and Transformer Thermal Analysis*, Report by the Electric Power Research Institute, February 17, 2017. See <https://www.epri.com/#/pages/product/3002009001/>.

^{viii} On September 2, 1859, the largest solar storm ever recorded propelled an intensely powerful coronal mass ejection (CME) directly at Earth. Called the Carrington Event, this CME destroyed most of the telegraph systems – the leading technology of its day – in the Northern Hemisphere and in Europe.

^{ix} “Earth’s Greatest Threat: The Sun and Its CMEs,” by Eric McLamb, *Ecology.com*, May 1, 2014. See <http://www.ecology.com/2014/05/01/earths-greatest-threat-cmes/>.

× CIPA was signed into law in December 2016 as part of the 2017 NDAA. It directs DHS to undertake a review and comparison of the risks and consequences of man-made and naturally-occurring EMP on the U.S. critical infrastructure and to report to the House and Senate Committees on Homeland Security, and the House and Senate Select Committees on Intelligence how the United States can best protect its critical infrastructure against EMP and related threats.

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