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14. ABSTRACT
American success in past conflicts has relied on superiority of US technology on the battlefield. However, this superiority is now challenged. According to a Defense Science Board (DSB) Report from August 2011 and the 2004 Executive Report to Congress from the Commission to Assess the Threat to the United States from Electromagnetic Pulse Attack, the US tactical forces potential lack of resiliency to electromagnetic pulse (EMP) is a consequence of many factors. The adversary's use of a high altitude electromagnetic pulse (HEMP) will generate a decisive advantage over friendly forces if equipment is unprotected against this threat. DoD policies on HEMP expanded beyond strategic systems to protect tactical assets will mitigate potential adverse effects. With the inclusion of tactical assets in the revised DoD policy, the procurement and acquisition of HEMP survivable equipment will ensure that warfighters possess the adequate capabilities in a future operating environment where an adversary is capable of employing a HEMP as a means of delaying, disrupting, and defending against friendly forces.

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Future War Paper

Denying the Adversary's Capability to Level the Playing Field: Critical Policy Changes to Harden, Protect, and Shelter Maneuver Assets Against an Electromagnetic Pulse

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF OPERATIONAL STUDIES

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THE OPINIONS AND CONCLUSIONS EXPRESSED HEREIN ARE THOSE OF THE INDIVIDUAL STUDENT AUTHOR AND DO NOT NECESSARILY REPRESENT THE VIEW OF EITHER THE SCHOOL OF ADVANCED WARFIGHTING OR ANY OTHER GOVERNMENTAL AGENCY. REFERENCES TO THIS STUDY SHOULD INCLUDE THE FOREGOING STATEMENT.

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Figures

American success in past conflicts has relied on the superiority of US technology on the battlefield. However, this superiority is now challenged. According to a Defense Science Board (DSB) Report from August 2011 and the 2004 *Executive Report to Congress from the Commission to Assess the Threat to the United States from Electromagnetic Pulse Attack*, the US tactical forces potential lack of resiliency to electromagnetic pulse (EMP) is a consequence of many factors. One factor is the migration to electronic capabilities and software-driven system architectures for many of our combat capabilities, which are vulnerable to an EMP. A second factor is a perception that the electronic warfare threat has disappeared since the end of the Cold War, causing a shift in US attention away from EMP. A third factor is the acknowledgement that potential adversaries of the US have observed their tactics, techniques, and procedures for battlefield electronics and learned that they are heavily reliant on electronics and electronic systems on the battlefield. The emerging threat environment is characterized by a wide spectrum of actors that include near-peers, established nuclear powers, rogue nations, subnational groups, and terrorist organizations that either now have access to nuclear weapons and ballistic missiles or may have access over the next 15 years place the risk of EMP attack and the associated adverse consequences on the US at an unacceptable level.[1]

The adversary's use of a high altitude electromagnetic pulse (HEMP) can potentially generate a decisive advantage over friendly forces if equipment is unprotected against this threat. DoD policies on HEMP expanded beyond strategic systems to protect tactical assets initiates a plethora of efforts to mitigate the potential adverse effects. With the inclusion of tactical assets in the revised DoD policy, the procurement and acquisition of HEMP survivable equipment ensures that warfighters possess the adequate capabilities in the future operating environment where an adversary is capable of employing a HEMP as a means of delaying, disrupting, and defending

against friendly forces. Moreover, the expansion of current DoD policy provides a basis and strategy for requirements generators to relate affordability and mission effectiveness while applying priorities to implement EMP survivability into future tactical systems.

During nuclear testing in the 1950's, attention slowly began to focus on EMP as a cause of electronic equipment malfunction. It was not until further testing around 1960 that the possible vulnerability of electrical and electronic systems to EMP was recognized.[2] Characterized as the production of a very short (hundreds of nanoseconds) but intense pulse, an EMP propagates away from its source with diminishing intensity and is governed by the theory of electromagnetism.[3] This pulse of energy produces a powerful electromagnetic field within the vicinity of the weapon burst and across the affected area on the ground, a radius of hundreds of miles from the burst site, and affects the entire area simultaneously.[4] The height of the blast increases the affected area on the ground.

An EMP is one of the many products of a nuclear explosion. The intensity, duration of the pulse, and area affected vary greatly with the altitude of the burst. The strongest electric fields are produced near the burst by detonations at or near the earth's surface, but for those at high altitudes, the fields at the earth's surface are strong enough to be of concern for electrical and electronic equipment over a much larger area.[5]

A nuclear HEMP is a time-varying burst of electromagnetic radiation that increases rapidly to a peak. The electric field strength then falls off and becomes quite small in a few tenths of microseconds (more rapidly in an air burst compared to surface burst).[6] Though this may seem like a very short pulse, the energy is substantial and is related to the yield of the weapon detonated (i.e., kilotons). The negatively charged electrons move outward faster than the heavier positively charged ions, creating a separation of charges, thereby creating an electric

field. If the nuclear burst were to occur at high altitude (40km or above), the gamma rays would encounter an atmosphere with decreased air density. This would enable the gamma rays to travel greater distances before being absorbed. The gamma rays traveling in a general downward direction would encounter an atmosphere that is increasing and forming the "deposition" (or source) region for the EMP (Figure 1).

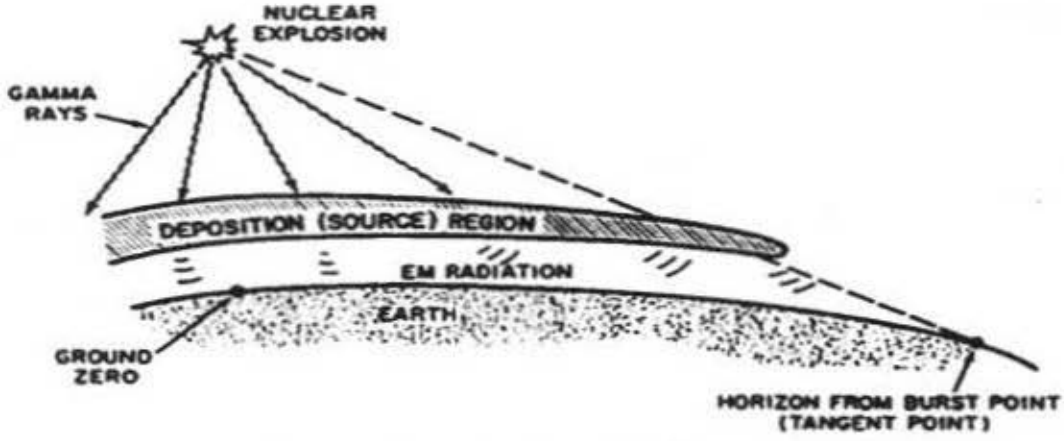

Figure 1: Origin and Nature of EMP[7]

As the electrons accelerate toward the earth along the atmospheric magnetic field, they create an avalanche effect with transient electrical fields and currents responsible for the electromagnetic pulse with frequencies between 100KHz and 1GHz. The electromagnetic pulse is characterized by fast, medium, and late arriving energy or E1, E2, and E3 respectively. The fast traveling or E1 pulse produces a propagation effect that induces fields, currents, and voltage, which damage electronic components, subcomponents, and systems. The E2 pulse, although lower in peak power of its electrical shock, follows a fraction of a second behind the E1 and destroys the components impaired by the first shock. The third component, E3, compounds the effects of E1 and E2 by creating a disruptive current lasting tens of seconds to minutes. As an example of the damage created by a high-yield EMP, the Soviet Union tested a series of exo-

atmospheric nuclear detonations in 1962 using 300-kiloton weapons and reported damage to overhead and underground cables out to 600 kilometers, as well as "surge arrestor burnout, spark-gap breakdown, blown fuses, and power supply breakdowns."[8] However, high-yield weapons are not necessarily required to produce an EMP. Studies suggest that low-yield nuclear weapons have the potential to produce a significantly larger EMP than a high-yield nuclear weapon. Of note, the four North Korean nuclear tests from 2006-2017 have had yields of one to ten kilotons.[9]

Low-yield nuclear weapons, referred to as Super-EMPs, are a category of EMP that is specially designed to produce primarily gamma rays that generate only an E1 electrical field. One specific design of a Super-EMP warhead would be a modified neutron bomb, more accurately an Enhanced Radiation Warhead that produces not only a large amount of neutrons but, large amounts of gamma rays that cause the EMP effect.[10] These Super-EMPs can have an explosive yield as small as one kiloton and are reported to be able to generate 200 kilovolts per meter (kV/m), whereas a high-yield (20 megaton) weapon generates 30 kV/m. The Super-EMPs' effects on tactical forces would have strategic-level repercussions as compared to a high-yield nuclear detonation or a surface burst.

Compared to the high-altitude burst, a surface burst will drop off rapidly with distance. For an explosion of high yield, the EMP will extend in all directions on the ground as far as the line of sight from the burst point. Additionally, lower frequencies will constitute a significant pulse extending beyond the horizon. For example, a nuclear explosion at an altitude of 30 miles will have an affected ground radius of roughly 480 miles, whereas a burst height at an altitude of 300 miles will affect a ground radius of 1,470 miles. Since the radiation travels with the speed of

light, it is expected that the entire area will be affected simultaneously, with instantaneous effects on electrical equipment (Figure 2).[11]

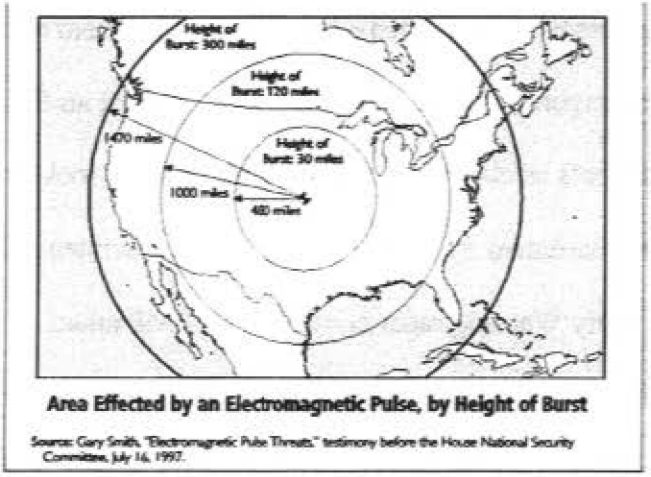

Figure 2[12] Area Effected by an Electromagnetic Pulse, by Height of Burst

Throughout the Cold War period, scientists around the world directed attention to the proliferation of nuclear weapons. As nuclear weapons testing and evaluations were conducted, the EMP was first recognized only as a collateral effect. However, this capability metastasized into the capability to conduct an EMP attack. In 1962, the Soviet Union experimented with atmospheric explosions. The best-known test is Operation K or Test 184 over Kazakhstan, which used a 300-kiloton weapon yield at an altitude of 290 kilometers.[13] As a sign of proliferation of EMP-capable weapons, at a 1999 Congressional delegation in Vienna with senior Russian government officials, Vladimir Lukin, the chairman of the Duma's Foreign Affairs, threatened, "If we really wanted to hurt you with no fear of retaliation, we would launch a submarine-launched ballistic missile (SLBM), [and] we would detonate a nuclear weapon high above your country and shut down your power grid."[14]

Other potential adversaries such as China, North Korea, and Iran also possess the capability to use EMP weapons. China has institutionalized the use of EMP as a first strike capability in wargames. North Korea, although considered an indigenous nation, is considered to

be a nation associated with the AQ Kahn proliferation network.[15] In 2004, Russia warned that design information was provided to North Korea that may give it the capability to build a Super-EMP. The North Koreans have conducted a bomb test with a yield of about ten kilotons, which although dismissed by experts, is the exact amount required for an EMP. Additionally the trajectory of North Korea's satellite launch of December 2012, looked very much like a Fractional Orbital Bombardment System (a Soviet innovation intended to exploit limitations of US Ballistic Missile Early Warning radar coverage) for EMP attack.[16] Although North Korea's possession of this capability is concerning, the greater concern is the country's potential to sell missiles and technology to other rogue nations. North Korea and Iran are strategic partners with a treaty between the two countries that obligates the sharing of scientific and military technology.[17] Iran has tested its Shahab-III ballistic missile in a mode consistent with an EMP from both a land and ship platform.[18] US policy makers should distill that the collaborative efforts of these nations can have a profound impact on future operating environment.

Adversaries that possess sophisticated and unsophisticated missiles armed with nuclear weapons may employ an EMP to create a regionally asymmetric environment to target maneuver forces to level the playing field. At high altitude, the effects of the detonation of a nuclear warhead (i.e., the blast, thermal radiation, radioactive fallout) would not be experienced by people at the ground level. Moreover, an EMP is not reported to have direct harmful effects on people. Therefore, it is anticipated that instead of destroying cities, bases, and people, an adversary will employ an EMP to obtain an asymmetric advantage on the battlefield.[19] Further, EMP is a method that an adversary could use to neutralize the technological advantage with a single blow to US forces. Because of these far-reaching effects, the US has taken steps to mitigate damage to critical infrastructure.

Many US strategic systems are hardened or shielded against an EMP, and DoD Instruction 3150.09, Chairman of the Joint Chiefs of Staff (CJCS) Instruction 3222.01, and Chief of Naval Operations Instruction 3401.3B established procedures for the execution of EMP protection; however, the systems used by maneuver units are still largely vulnerable. Further, the US vulnerability to EMP is increasing because of the growing dependence on unshielded electronics, especially the commercial systems that are the cornerstone of modern high-technology equipment.[20] The increasing dependence on commercial-off-the-shelf (COTS) systems to support military operations is attributed to the ability of such systems to provide cost-effective solutions expeditiously to the warfighter. However, there is a downside when considering the survivability of these COTS solutions against an EMP.

As reliance on COTS technology grows, so do the threats and consequences of an EMP to maneuver units. COTS electronics such as electronic fuel injection systems on vehicles are particularly vulnerable to EMP effects. Moreover, the copper wiring between devices requires limited energy to permanently destroy them.[21] In the instances that the equipment is not destroyed, it may still function but with expected degradation. Although the cost to shield or harden existing systems might be cost prohibitive, next-generation systems can integrate shielding in the design phase for a five to ten percent increase in cost. However, after the system is fielded to the operating forces, the cost of hardening may be as much as it is to build.[22]

A potential target of an EMP among mobility assets is the group of systems that operators take for granted, primarily the electronic components and subcomponents within a vehicle's operating system. For example, in 2008 a Logistics Vehicle System (LVS) (Figure 3)[23] experienced a direct lightning strike that required the replacement of the preponderance of electronics on the vehicle.[24] Although an EMP and a lightning strike are different in some

respects, particularly that it is unlikely that an adversary-generated EMP would result in the same external visual and physical damages on an asset as a lightning strike, the effects on the asset's operational capabilities are essentially the same. Further, the level of maintenance required to repair the asset is above the capability of a general maintainer or vehicle operator and is a depot-level repair problem. Therefore, the argument to carry redundant repair parts does not hold. Ultimately, the use of an EMP would have the effect of leveling the playing field for an adversary of the United States.

Figure 3: LVS Disembarking from an LCT During an Amphibious Exercise

The EMP Commission, established pursuant to title XIV of the Floyd D. Spence National Defense Authorization Act for Fiscal Year 2001, tested the vulnerabilities of a number of automobiles and trucks ranging in vintage from 1986-2003. These vehicles all had extensive electronic systems, including up to 100 microprocessors that controlled virtually all functions. The tests compared vehicles that were operating and shut off at the time of exposure to EMP. Although there were no effects on vehicles that were shut off, the EMP Commission stated that "at least two out of three automobiles on the road will manifest some nuisance response at twenty-five kV/m or higher."[25] Of the trucks tested, thirteen of the eighteen experienced a response while running. The results of the EMP Commission's work showed that at levels higher

than twelve kV/m, seventy percent of trucks on the road will experience some type of anomalous response.[26]

Although the requirements generators will need to best determine how the above stated five to ten percent increase in cost is applied, the focus should be on shielding the systems most vulnerable components, such as the radio and transistor based control systems, which includes the alternator, the power plant, and the ignition system. These critical subsystems could employ a Faraday cage[27] and bonding to the electrical ground of the chassis with filtering and surge protection at each point of entrance.[28] Furthermore, the control system wiring can be routed through welded conduit between the critical subcomponents. Also, to mitigate any unintended conducted energy onto the wiring system all wire penetrations need filtering and protection. These protections could mitigate the vulnerabilities addressed by the EMP Commission's report.

Due to the lack of EMP protection policy directed at tactical military systems, it is essential that the DoD establish initiatives and policy to direct analysis and hardening of next generation vehicles. This will provide the acquisition professionals with the formal documentation necessary to justify the research and development required to protect tactical and logistics support vehicles against the threat of EMP.

Over the past 15 years, US forces have been involved in both major combat operations and crisis response missions resulting in a counterinsurgency (COIN) paradigm. Unlike the Soviet Union during the Cold War, the adversaries in Iraq and Afghanistan have lacked the sophistication required to employ a regionally asymmetric weapon that would significantly challenge US forces to the degree that an EMP would. The COIN paradigm has also significantly affected the US approach to the development and procurement of equipment for combat operations. The lack of a sophisticated threat and need to rapidly field equipment has created a

separate but related paradigm in the COIN fight. The requirement for systems to operate in a electromagnetic contested environment was not necessary and therefore not included in the design. The resulting paradigm is a portfolio of systems fielded to the force that are not designed to operate against a sophisticated adversary who possesses an asymmetric weapon such as an EMP. Though these paradigms have resulted in an unbalanced overall portfolio of weapons systems, it can be rebalanced within the requirements process to incorporate the necessary capabilities to fight both unsophisticated and sophisticated adversaries.

Requirements generators and system program managers have accepted the heuristic to drive costs lower and shorten deployment times for systems reinforced with ideas that have come out of documents such as a 2009 report of the Defense Science Board Task Force on integrating commercial systems into the DoD. According to the report, the DoD should adopt effective and efficient acquisition strategies specifically aimed at COTS and government-off-the-shelf (GOTS) products in order to satisfy mission needs. These COTS and GOTS solutions will take advantage of the speed of deployment and low cost needed for future military systems.[29] Moreover, Dr. William Schneider, the Chairman of the Defense Science Board, states, "Purchasing commercial or other government off-the-shelf (COTS/GOTS) and commercial- or foreign-derivative systems presents a significant opportunity to the DoD. The challenge is to reap the advantages—including predictable and lower costs and short realization schedules." Later in the report, he states, "while a military system designed from the bottom up can deliver a total solution to an identified requirement, the goal of using COTS/GOTS and commercial- or foreign-derivative systems is to get the '80 percent' solution fielded rapidly and at a much lower cost and risk."[30] Though COTS/GOTS technology and products have been an asset in recent engagements, they

have contributed to the imbalance in our portfolio as they are not purpose-built to defend against the EMP threat.

In 2011, within the Departments of the Navy, Air Force, and Army, 318 items met the EMP survivability requirement.[31] Though the authors were unable to ascertain the total number of items within the respective departments, it can be safely assumed that 318 items equates to an extremely low percentage when considering the aggregate number of items that exists within the DoD, meaning the preponderance of systems are unprotected. As stated earlier, the strategic forces are hardened and protected in accordance with established policies, but for systems within the DoD that are not considered strategic, the need for protection against an EMP falls outside the "80 percent" solution.

The absence of a documented requirement for a system to operate in a HEMP environment, the cost and increased time for deployment has led requirements generators and program managers to accept the trade-off for lower cost and shorter development and deployment times over hardening against a HEMP. The research conducted by the authors discovered several justifications regarding the trade-off between hardening, cost, and deployment of systems. Though nuclear testing in the 1950-1960s clearly indicate effects of EMP on electrical systems, the most frequently documented justifications for not harden equipment against EMP is that these effects have not occurred in the operating environment. Further, requirement generators dismiss the sophistication of our adversaries and the future operating environment. Another justification is that in a fiscally constrained environment, the money could be allocated elsewhere. In the case of tactical vehicles, there is not a requirement to harden and protect these assets against the EMP threat.[32]

The accepted trade-off between cost and hardening is troubling when considering recorded Congressional testimony in 2006 that indicates incorporating a plan for hardening a new tactical item against an EMP may increase the cost of the device only five or ten percent.[33] Research presented in the *Report of the Commission to Assess the Threat to the United States from EMP attack* states that the cost could be as little as one to three percent if executed at the time the unit is designed and manufactured.[34] All research indicates that waiting until the device is built will significantly increase the cost. In fact, the 2006 Congressional testimony indicated that it may cost as much to harden the device after its construction as it did to build it.[35]

Solution

DoD policy must be amended to ensure that technical solutions are developed and that US forces, as a system, are protected against the effects of an EMP attack. The last 15 years of operating in a counterinsurgency environment has eroded the forces' ability to plan for EMP survivability and given rise to the perception that an EMP is an acceptable risk because it is seemingly small. Testing and simulation facilities, institutional knowledge, and research and development have been minimized to support other efforts. However, with US adversaries gaining possession of EMP weapons, the adverse consequences present a risk to the force and mission that cannot be ignored—the level of risk is on par with the US lack of preparation to fight the Japanese in December 1941.[36] The future operating environment requires that tactical forces be resilient to an EMP attack. To ensure that this tactical capability is supported, the current policy[37] (i.e., DoD Instruction 3150.09 and CJCS Instruction 3222.01) should be expanded to include tactical forces. By expanding these policies to protect tactical forces, requirements generators and acquisition professionals can justify the additional cost to conduct research and development for technical solutions. These technical solutions, if funded during the

design phase, will increase costs; however, the cost is minimal when compared to the cost of upgrading currently fielded equipment or repairing equipment damaged by an EMP. Further, US forces must reevaluate how "systems" are defined to ensure that vulnerabilities are accurately assessed against mission requirements.

The military's tactical force lacks a thorough assessment of vulnerabilities to the effects of an EMP. The assessments that have been conducted thus far have focused primarily on tactical command, control, communications, and computer systems such as satellite navigation systems, satellite and airborne intelligence, targeting systems, and communications infrastructure. However, the capability to quickly move the assets listed above requires logistics vehicles, primarily the tactical vehicles that are not currently hardened and protected against an EMP and for which there are no acquisition requirements to do so.[38] This fact was addressed in the 2004 Report of the EMP Commission, which stated, "This [the DoD acquisition process] has provided many equipment components that meet criteria for durability in an EMP environment, but this does not result in confidence that fielded forces, as a system, can reliably withstand EMP attack."[39]

The US tactical forces are dependent on multiple components operating together to achieve superior battlefield effects over the adversary. The integrated aspects of the components, the interaction between the components need to be protected as a system. For example, trailer mounted/towed combat power systems, such as artillery, requires a logistical asset to move around the battlespace. The loss of the capability to move the asset (mounted or towed) will impact the combat power that US tactical forces can bring to bear on the adversary. Regardless of whether the vehicle is inclusive or exclusive of the system, the holistic capability is not protected against an EMP.

Therefore, DoD should identify all the systems necessary to maintain the ability to fight in the future operating environment, which will be defined by the credible threat of EMP attacks to delay, defend against, and disrupt US tactical forces. This will require a holistic approach to reassess how systems are defined. Currently, as stated above, the acquisition system does not identify a vehicle as part of the system to support towed artillery. Rather, the vehicle and artillery are identified as two distinct and separate systems. To further illustrate this point, there are a required number of trucks to logistically support a company of tanks. Although the degradation of one truck will not render the tank company non-mission capable, the unit as a whole would be degraded in a combat environment if multiple trucks were rendered inoperable by an EMP because the unit relies on those trucks to support its forward advance in conducting exploitation operations.

During the Cold War, the US response to the threat of EMP was confined to shielding critical components of strategic forces. Military Standard 188-125 released on 26 June 1990 is a directive that requires EMP mitigation for all military command, control, communications, and computer systems. Subsequently, the DoD issued DoDI 3190, which establishes policy, assigns responsibility, and establishes procedures for the DoD Survivability Policy. By expanding this policy to include the tactical forces and reassessing the manner in which operating systems are defined, strategies can be developed to ensure that fielded forces are confidently hardened and protected against an EMP attack.

Conclusion

Adversaries of the US are focusing on and studying the technological advances of US forces and the US reliance on technology. China specifically mentions this in its military doctrine as a critical vulnerability for the US.[40] The DoD must undertake a 21st century approach

to fighting in a contested environment, and that approach must start with a critical analysis of our warfighting equipment and ensure that the DoD is fielding equipment that is capable of operating against a sophisticated adversary. The US military can only maintain its core capabilities of maneuvering against an adversary by protecting its electronics and electrical systems. Protecting these components against EMP attack will allow the US to maintain its technological advantage. Though an EMP weapon has not been brought to bear against US forces, the unmitigated risk exists. Over the past 15 years, our adversaries have observed and learned much from how we operate. They have seen how US forces used and relied on maneuver warfare to gain and maintain the advantage. Our adversaries will use that knowledge to oppose US forces, and the United States must be prepared to counter the threat. The current policies need to be expanded to incorporate EMP survivability functions within existing DoD decision-making processes and ensure warfighters are provided with HEMP survivable systems.

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[23] The LVS is a complementary asset to the Medium Tactical Vehicle with a 22.5-ton on-road/16.5-ton off-road payload. The vehicle is used to haul flatrack cargo, containers, bridging equipment, boats, and fuel containers.

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[25] House Committee on Armed Services, *Threat Posed by Electromagnetic Pulse (EMP) Attack: Critical National Infrastructure,* 111th Cong., 2nd Session, Jul 10, 2008, p. 115.

[26] House Committee on Armed Services, *Threat Posed by EM) Attack: Critical National Infrastructure,* p. 116.

[27] Electromagnetic waves are two waves in one. An electrical wave creating an electrical field moves along one plane, and a magnetic wave creating a magnetic field that moves perpendicular to the electrical field, as shown below. The two fields feed off each other, creating a self-propagating wave. Both of these fields are thwarted by the Faraday cage, but in different ways. The field causes the electrons in the metal of the cage to rearrange, neutralizing any charge within the cage. Faraday also illustrated this phenomenon with an ice pail. When magnetic waves come in contact with the Faraday cage, they create a current in the conductor known as an eddy current. (A moving magnetic field always generates a current in conductors — that's called electromagnetic induction). These eddy currents, in turn, create magnetic fields that oppose the field of the oncoming waves. So those waves are blocked from the interior of the cage. (https://nationalmaglab.org/about/around-the-lab/what-the/faraday-cage, accessed 10 March 2017)

[28] Mark Hendricks, "EMP Mitigation: Protecting Land Mobile Vehicles from HEMP Threat Environment," Smiths Power White Paper, http://www.smithspower.com/SiteMedia/SiteResources/WhitePapersandTechnicalNotes/1474-001.pdf?ext=.pdf, accessed on 25 Feb, p. 5

[29] Office of the Under Secretary of Defense, "Buying Commercial: Gaining the Cost/Schedule Benefits for Defense Systems," February 2009, http://www.acq.osd.mil/dsb/reports/ADA494760.pdf (accessed 17 Dec 2016), p. xi.

[30] Office of the Under Secretary of Defense, "Buying Commercial," p. xi.
[31] John Kuspa, "DoD Nuclear Survivability Program," http://www.dtic.mil/ndia/2011CBRN/Kuspa.pdf (accessed 10 Nov 2016).
[32] Email between LtCol Michael and Mr. Jay Proctor.
[33] Congressional Committee on Armed Services, "National Security and Electromagnetic Pulse."
[34] Dr. John S. Foster, Jr., et al., "Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack, Volume 1, Executive Report, 2004," p. 14.
[35] Congressional Committee on Armed Services, "National Security and Electromagnetic Pulse."
[36] In 1941, the US was unprepared to conduct operations across the vast distance of the Pacific Ocean due to the lack of ships, the ability to conduct amphibious operations, and all the tasks that amphibious operations imply, which includes the ability to get troops and logistics from ship to shore.
[37] The current policies direct that strategic forces, and command, control, communications, computers, and intelligence be protected against EMP attack.
[38] Email between LtCol Michael and Mr. James Proctor, Project Manager (MHTV) dated 7 Nov 2016.
[39] Foster, et al., "Report of the Commission to Assess the Threat to the United States from EMP Attack," p.48.
[39] Woolsey and Pry, "EMP Blackout Could Be Closer Than You Think."

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