Statement by Dr. Lowell Wood

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"If you would have peace, prepare for war."

– Benjamin Franklin

I am grateful for the Committee's kind invitation to offer testimony today on electromagnetic pulse (EMP) and its implications for our Nation's military capabilities and, indeed, for the continuation of American civilization.

BACKGROUND. I have been an interested observer of both American and foreign capabilities with respect to electromagnetic pulse (EMP) phenomena for three decades, and I have been actively involved with both offensive and defensive aspects of electromagnetic pulse weaponry for the past quarter-century. During the '70s, I served on the Defense Nuclear Agency's Scientific Advisory Group on Effects (SAGE), the DoD's senior technical review group concerned with nuclear electromagnetic pulse, as well as all other military nuclear issues having a technical character. In the late '70s and early '80s, I worked on "Third Generation" nuclear weaponry, a major component of which was nuclear explosive-driven generators of electromagnetic pulses of potentially greatly increased efficiency and military effectiveness; spinoffs involving non-nuclear means of generating potent EMP also engaged my attention. Later in the '80s and early '90s when strategic defense was emphasized, I worked on the development of defensive technologies of very high efficacy against nuclear EMP, with particular reference to military space systems. With the fall of the Soviet Union, my attention in these respects has turned to the implications of EMP in a nuclear-multipolar world, while remaining mindful of the EMP implications of the enduring Russian strategic nuclear force structure.

I have been privileged to appear on a number of occasions before the Subcommittees of the Armed Services Committee of the House of Representatives during the past quarter-century, testifying on a variety of national security topics; I last testified here on the subject of nuclear EMP in July 1997, and I also testified on this subject earlier this year before the Small Business Committee's Subcommittee on Government Programs and Oversight. I have served the Armed Services Committee in a technical advisory capacity, initially under Chairman Les Aspin over a decade ago, and more recently under the leadership of Chairmen Floyd Spence and Duncan Hunter.

SOME HISTORICAL PERSPECTIVE. More than a third-century ago, due both to commentary from our British allies and to some truly striking experimental results, military technologists in the United States became generally aware that high-altitude nuclear explosions often generated electromagnetic effects of completely unprecedented magnitudes, physical and temporal scales – and effects on both the physical environment and human handiwork. (It had been appreciated in a rather qualitative manner for some time previously by American workers that electromagnetic phenomena of singularly large magnitudes and quite exotic natures occurred in the immediate vicinity of nuclear fireballs created near the Earth's surface, but these effects were largely ignored against the background of the nuclear explosion-unique blast and heat effects.)

The first American high-altitude nuclear weaponry experiments after the Soviet breaking of the nuclear test moratorium of '58-'61 revealed a wealth of phenomenology of completely unprecedented – and largely completely unanticipated – character. Most fortunately, these tests took place over Johnston Island in the mid-Pacific rather than the Nevada Test Site, or "electromagnetic pulse" would still be indelibly imprinted in the minds of the citizenry of the western U.S., as well as in the history books. As it was, significant damage was done to both civilian and military electrical systems throughout the Hawaiian Islands, over 800 miles away from ground zero. The origin and nature of this damage was successfully obscured at the time – aided by its mysterious character and the essentially incredible truth.

Intensive effects commenced to understand what had happened – and what might happen in the event of hostilities involving high-altitude nuclear weaponry usage. These efforts were spurred by the knowledge that the Soviets had experimented extensively with high-altitude nuclear weaponry, including some uniquely high-yield explosions, during their '61-'62 test series, and presumably understood the implications of these at least as well as we did. American efforts were complicated by the cessation of

high-altitude testing associated with implementation of the Atmospheric Test Ban Treaty in '63, so that access to experimental truth was greatly complicated and, in some crucial respects, entirely precluded.

At this point, the Soviet Union and the United States commenced to engage the nuclear EMP issue somewhat analogously to two men fencing with very sharp blades in utter darkness: both knew that the weaponry which they wielded was extremely potent, but neither knew the other's time-varying posture, let alone the precise location of either vulnerable spots or especially well-armored ones. This deadly duel continued for three decades, through the collapse of the Soviet Union. It continues today. It will continue into the foreseeable future. EMP crippling of the American military machine and of the modern American nation remain real prospects.

THE NATURE OF EMP. Electromagnetic pulse is sufficiently alien to ordinary human experience that it seems to many to be either magic or illusion. Such entirely understandable human reactions have not facilitated the development or implementation of apt responses to the profound threats which it poses, either by political or military leaders. Thus, a few operationally-oriented fundamentals may be of use:

EMP is really severe static electricity, everywhere, all at once. Without needing to understand the undeniably esoteric means by which EMP arises in various military circumstances, it suffices to recall that it presents itself as something closely akin to static electricity, extremely intense but exceedingly brief, everywhere within line-of-sight to a high-altitude nuclear explosion, "all at once." (This "static electricity" pulse is carried on radio-frequency electromagnetic waves of uniquely high intensity. The bomb's extraordinarily intense prompt radiations essentially transform the entire atmosphere underneath it into a gigantic radio transmitter-antenna radiating at maximum-possible intensity – for a very brief interval. The bomb's fireball, expanding rapidly in the presence of the Earth's magnetic field, gives rise to a second manifestation of EMP which is of particular significance for long metallic lines, such as electrical and telephone systems.)

Extended metallic structures within line-of-sight of the explosion – telephone and electrical lines, radio and TV antennae, fence wires, etc. – then serve to gather up the broadcast energy of EMP and deliver it into whatever they connect to, often with locally ruinous results which appear retrospectively to be basically similar to those resulting from a lightning-strike. However, since the damage occurs thousands of times more swiftly than does that of a lightning-strike, most types of lightning-protective devices are essentially useless. Since it travels at the speed-of-light, EMP arrives essentially instantaneously, from the general direction of the explosion.

EMP can blanket an entire U.S.-sized continent from a single source. EMP originates primarily in the interaction of gamma-radiation from a nuclear explosion with the Earth's atmosphere at altitudes of a few dozen kilometers and propagates predominantly toward the Earth's surface. (The low-frequency, long-time component of EMP arises from fireball interactions with the Earth's magnetic field, as already noted.) Thus, since you can readily see a bomb explosion a few hundred kilometers above the central U.S. from anywhere in the "lower 48", the EMP arising from that explosion's interactions with the Earth's atmosphere can also "see" you.

To be sure, at greater distances, the intensity of the pulse will be smaller, but usually not as indicated by the familiar inverse-square-of-the-distance law. Likewise, its severity is generally not well-related to the yield, or total energy production, of the bomb. (The initial sharpness of the EMP actually depends rather sensitively on esoteric aspects of the bomb's design and operation. Low-yield specially-designed bombs may pose as large – or ever larger – EMP threats, at both low and high electromagnetic frequencies, as do high-yield "ordinary" ones.)

EMP doesn't linger. Since it arises from a nuclear explosion's promptly-emitted gamma radiation interacting with the Earth's atmosphere, nuclear EMP goes away very quickly. It is a phenomenon of compelling interest only for time-scales of the order of microseconds – millionths of a second, although its long-time component may be present for milliseconds – thousandths of a second. (Within these time-frames, however, it can be quite dramatic in its effects.) It has none of the lingering characteristics of nuclear radioactivity or fallout.

EMP isn't sensed by people, and it doesn't damage the human body. The nervous system and associated sensory faculties of people are essentially totally insensitive to electromagnetic radiation of the frequency, intensity and the time-duration of EMP. We don't sense it in any way. Because it arises and then goes away so exceedingly quickly, electrical currents due to it do not really begin to flow within our bodies, and no physiological damage of any kind takes place. EMP really "speaks" only to metallic objects, and to things connected to them which are sensitive to high-frequency currents.

EMP is much more threatening to big electrical systems than to small ones. Because metallic objects of many different shapes can effectively gather up and then concentrate the energy associated with EMP, physically large systems comprised of metal – lines, cables, wire and dish antennae – often manifest exceptionally great vulnerability to EMP damage. Their spatially extended components "harvest" the EMP energy broadcast by the bomb-atmosphere interaction, which falls fairly uniformly over wide areas, and bring it to wherever the system's "barn" may be – the often-centrally located components of the extended system which may be quite sensitive to electrical overload conditions. Physically small systems usually don't get EMP "illumination" so well-collected or -focused within themselves, and thus tend to be more durable to its effects. An obvious exception to this smaller-is-safer rule-of-thumb are communications systems, whose antennae and high-sensitivity "front ends" almost unavoidably make them highly vulnerable.

EMP is much more threatening to modern electronics than to old-fashioned ones. Older electrical and electronic systems are generally built out of massive components, which are innately much more tolerant of the effects of EMP. Vacuum tubes, for example, are extremely EMP-rugged, while the ever-tinier transistors which have almost totally replaced them in the U.S. military machine – as well as in U.S. civilian electrical/electronic systems of all types – are ever-more-vulnerable to EMP destruction. (Moore's Law – which states that leading-edge integrated-circuit electronics shrink in area by two-fold every year-and-a-half – assures that this vulnerability will become ever more severe, into the foreseeable future.) The Soviet technological lag behind the Americans has constituted a substantial – and vigorously exploited – advantage in this somewhat perverse respect.

EMP in space is different from EMP near the ground, and is typically nastier. EMP arising in spacecraft due to exposure to nuclear hard-x-ray and gamma radiations – even from great distances – is often extremely tedious to eliminate effectively and with adequately great assurance. (It is assuredly possible to accomplish, however, even against the most severe threats, although it is often quite costly to do so.)

Nuclear EMP thus poses an extremely serious threat to the assured functional survivability of space assets, both military and civilian, the more so as the essential system-level testing always was expensive and currently is effectively impossible.

EMP defenses are simple, and traditionally have added ~10% to military system costs. For typical military systems which do not operate in space, the rule-of-thumb has been that robust hardening against EMP effects adds 3-10% to the total system life-cycle cost – "the cost to the Nation to own" – if such hardening is engineered-in from the outset. For systems which are mass-produced, the EMP hardening cost may be as low as 1%, while few-of-a-kind items such as the MILSTAR spacecraft may have a fractional cost attributed to wartime survivability of a few tens of percent. (To be sure, cost attribution in DoD often is a political art, not an economic science.)

Such hardening consists primarily of high-integrity albeit thin (e.g., tinfoil-like) metallic shielding to keep the EMP radiation out of enclosed volumes containing vulnerable systems components and of special electrical devices – e.g., high-tech analogs of lightning arresters – for protecting absolutely essential penetrations of such seamless metallic enclosures from inadvertently admitting significant amounts of EMP energy into the interior "sanctuary." The major fractions of the added-cost for EMP hardening have traditionally been spent in engineering design, prototyping, performance-testing and life-cycle maintenance of EMP-robustness, not in the mass-production of the "sanctuary" itself. Indeed, significant economies might be realized in these cost-dominating areas in future efforts by intelligent use of more modern technologies, particularly commercial ones which have been very effectively employed in the past several years. If, on the other hand, EMP hardening is back-fitted to an existing military system, costs have generally been in the neighborhood of 10% of total system cost-to-the-nation-to-own.

Quite notably, substantial EMP hardening of a wide variety of COTS – commercial off-the-shelf – equipment (e.g., personal computers and communications gear) currently being acquired by the Services has been demonstrated to be attainable with a few dollars' worth of parts-and-labor.

SOME FUNDAMENTAL TECHNICO-MILITARY DIFFERENCES. There were several fundamental differences in the technical and military approaches which the Soviet Union and the United States took toward EMP. These differences are reflected in the postures of the two nations' military machines today, and likely will be enduring ones.

The Soviets basically decided that EMP represented not only an exceptionally severe threat to the integrity of their military apparatus and their civilian infrastructure, but also offered extraordinary opportunities to their strategic offensive forces. Relatively deficient in supercomputer-based computational modeling tools with which to understand the quantitative details of EMP generation and interaction with a wide variety of particular structures and systems, they took a generic, highly empirical "belt and suspenders" approach to protection of both military and civilian systems against EMP, deploying protective hardware quite lavishly (as compared to the U.S.) and providing extensive counter-EMP training to both civilian and military personnel involved in the operation and maintenance of these systems. This preparative excellence continues virtually undiminished through the present time.

Soviet strategic strike forces characteristically have featured weaponry well-suited to efficient EMP generation over exceptionally wide areas. That EMP strike component exists today in the Russian strategic order-of-battle, moreover likely at its maximum Cold War strength. I very confidently predict that it will be one of the last features of Soviet strategic nuclear weaponry to be retired from the Russian strategic force structure. It has long been considered highly likely by U.S. strategic war planners that a Soviet first-strike would commence with a multi-explosion "laydown" of high-intensity EMP all over the continental U.S., significantly before any target on the ground is brought under attack, simply because the cost of such an attack-commencement is low and the benefits gained are great. Indeed, recollections of strategic war games long past have as a major common feature the beginning of the game with a massive Soviet EMP laydown all over the U.S., followed immediately by an extended "time-out" while the game's referees rip up huge handfuls of U.S. military capability of all types and throw it away as likely EMP-ruined.

We Americans, in contrast, collectively saw EMP as a major nuisance which could be rather precisely understood, defended against "well enough" – and thereafter largely ignored. The Defense Atomic Support Agency (DASA), succeeded by the Defense Nuclear Agency (DNA) and then by the Defense Special Weapons Agency (DSWA) and currently buried somewhere in the Defense Threat Reduction Agency (DTRA), working in exceptionally fruitful long-term collaboration with dedicated components of American industry (of which the RAND Corporation Physics Department, later re-organized as R&D Associates, and the Mission Research Corporation were particularly distinguished leaders), developed a really outstanding technical appreciation of EMP, how to model and simulate it with high fidelity, and how to effectively defend major military systems against it. Indeed, I estimate that half of DASA/DNA/DSWA's third-billion dollar ('98 $) time-averaged annual budget was expended for purposes of defense against EMP and related nuclear effects, over an interval of three decades.

Programs then came into existence to express and embed this evolving understanding – excellent albeit imperfect – of EMP in major American strategic warfare systems, primarily the offensive ones but also the defensive components. However, because neither supercrats nor senior commanders really understood – or, in some cases, believed in the existence of – EMP and its effects, these EMP hardening programs too often followed uncertain trumpets, and their average effectiveness was not exceedingly high. (At that, U.S. strategic military systems were much better EMP-protected, on the average, than were our tactical ones.)

Some CINCs stand out in my memory as exceptionally diligent in their efforts, the results of which were especially praiseworthy. (A few senior Navy admirals, enjoying unusually great tenure and discretion over the resources of their large commands, did very well by the enduring National interest in these respects.) All too often, though, protecting against a poorly-understood, deemed-unlikely threat of a semi-magical character lost out in the unceasing battles-for-resources, and was deferred, largely or completely, to "next year" – a well-known point-in-time which is never quite attained in DoD-Land. In some notable EMP-

hardening programs, sustained and strenuous efforts were made without securing desired results, outcomes which were sometimes obscured to the present day by lack-of-candor leveraged with high security classifications. Case histories abound, but are not appropriate for open discussion.

As a result, the present-day U.S. strategic force structure is a veritable "patchwork quilt" with respect to its EMP durability. The bottom line is that, in "really bad weather", this "quilt" won't keep "warm" the fundamental National interest. This situation is undoubtedly known, even in many of its details, to our potential near-peer and sub-peer adversaries – and it presumably incentivizes their exploitation-directed efforts. At that, America's strategic forces may be substantially better-postured against EMP attack than are our day-to-day, tactical forces. However, I commend to your favorable attention the substantial ongoing efforts of the Services to attain improved EMP hardness levels of tactical military equipments of many kinds, dubious recent coordination efforts from the Joint Staff notwithstanding.

The EMP robustness of the civilian infrastructure of the United States can be summarized far less equivocally: it is entirely non-existent. Our civilian telephony, electricity, broadband communications and electronics plants are all naked to our nuclear-armed enemies. They were neither designed, nor engineered, nor constructed nor are they operated so as to survive nuclear explosion effects, even at very great distances – for the 'invisible hand' of the marketplace provides no incentives for EMP robustness, nor penalties for failing to so prepare. Large electric power and telephony systems are known to fail under the effects of solar storms, which impose far smaller electromagnetic stresses than are known to arise from high-altitude nuclear explosions of even modest scales. Consequently, even a modest, single-explosion EMP attack on the U.S. might well devastate us as a modern, post-industrial nation.

PECULIAR ASPECTS OF EMP ATTACKS. Indeed, a nuclear EMP attack on a nation is, in the large, the obverse of what the neutron bomb was asserted (utterly falsely by anti-deployment-directed Communist propaganda, but nonetheless with great political effect) to be in the small: an arch-capitalist weapon which killed people but didn't destroy the capital plant in which the people were located. EMP weaponry (potentially even in single copy), in acute contrast to this now-ancient canard, potentially destroys in a highly effective manner the high technology electrical/electronic plant of any advanced nation – the heartland of modern civilization – while not directly harming people at all.

It is profoundly unsettling that the electrical/electronic infrastructure of a large modern nation – which may be valued at more than ten thousand dollars per capita, or a few trillions of dollars for a nation such as the U.S. – can be so seriously threatened from afar by a single nuclear explosion, whose marginal cost may be a few million dollars, or a million-fold less. That this can be done without harming people – potentially even invisibly, if done in broad daylight – gives real pause for thought, in a still-troubled, nuclear-multipolar world. Nuclear EMP is the quintessential asymmetrical-and-unconventional threat.

ASPECTS OF THE INTERNATIONAL STATE-OF-PLAY. Several aspects of the current and likely-future geopolitical state-of-play seem impacted by such considerations.

Through the end of the Cold War, we Americans could "attribute" any EMP attack on us with exceedingly high confidence to precisely one source: the Soviet Union. Moreover, we usually anticipated that such an attack would merely comprise the precursor of a "mass raid on North America" and, as such, "will be met with a full retaliatory response." Toward the end of the Cold War, American strategic war planners worried about more nuanced Soviet attacks, possibly EMP-intensive ones involving quite limited damage-on-the-ground, and puzzled as to how to most appropriately respond to such damage-intensive but "casualty-poor" attacks. Such perplexities seemed to many observers to be largely obviated by the end of the Cold War and the cessation of such "virtual hostilities" with the Soviets.

But were they really? It is widely-known that we Americans contemplated, briefly and in a non-pervasive fashion, a nuclear EMP laydown on Iraq (a Non-Proliferation Treaty signatory legally entitled to immunity from all nuclear attacks) as an exceptionally high-effectiveness commencement to Operation Desert Storm – and that two-thirds of the American people polled on the subject in that season explicitly supported the use of nuclear weaponry to protect the lives of American troops. It certainly should not be surprising if other nuclear-capable nations were thereby stimulated – if indeed any such external stimulus

was needed – to contemplate employment of a similar tactic against their various politicomilitary adversaries, of which the U.S. may well be one.

What would the U.S. response be to a nuclear EMP "bolt from the blue" – or even one from a geopolitically overcast sky? What if such an attack, e.g., executed with a single rather modest Earth-orbiting bomb, arguably could have been mounted not only by Russia, but also by China or India or Pakistan or Iran – or North Korea? Particularly if none of our fellow citizens died as a direct-and-immediate result of such an attack, what degree of certitude of attack attribution would we require of ourselves before an American President would order a retaliatory strike imposing condign punishment on the suspect nation? Paralyzed as a modern nation, thrown back decades in time in industrial capabilities but still retaining a reasonably full set of nuclear teeth in our national mouth, just how would we Americans then choose whom to bite – if anyone?

That scenarios of this general flavor are currently considered "within the pale" is illustrated by the "Army 2020" war game conducted at Carlisle Barracks two years ago. Especially notable for its openness, this exercise postulated a U.S. expeditionary force in the Ukraine clashing with an invading Russian force, two decades hence. When the Russian force fared poorly in ground combat operations, the Russian General Staff used a set of nuclear explosions in space to effectively destroy the "high eyes and ears" of the U.S. military – and most civilian comsats and Russian space systems, as well – in order to express "national resolve." In addition to the far-distant Russian nuclear explosions giving American decision-makers real pause for thought, the entirely unexpected, abrupt and total loss of the "high ground" conferred by U.S. space assets nearly cost the American expeditionary force its collective skin. Just as this game was ending in a Russian-American armistice, the Chinese, noting America's unprecedented military incapacity, commenced to make their long-expected moves in the Far East . . . .

At that, wafting out of this unusually thought-provoking exercise was a faint aroma of "Blue-preferred Red responses," a well-known key ingredient of politicomilitary folly. The Army's game-designers were willing to postulate nuclear explosions in space of a flavor which acted over time-scales of hours to days to dramatically "burn down" American space assets largely owned-or-operated by the Air Force. However, these game-designers didn't care to consider an arguably equally plausible Russian nuclear EMP laydown over the Ukrainian territory within which the American expeditionary force was operating – which, without inflicting casualties directly, may well have devastated the electrical/electronic sinews of American tactical military assets – ones incidentally almost entirely owned-and-operated by the Army in this particular scenario.

Indeed, EMP laydowns constitute a generically attractive response on the part of any regional nuclear power – not just Russia – to virtually any American power-projection attempt. They exemplify what is termed a "technologically asymmetric response" to the impending Revolution in Military Affairs, one in which our adversary acts purposefully to leverage his set-of-strengths and exploit our set-of-weaknesses. (Saddam Hussein fought us entirely on our terms in Desert Storm; we must assume that we will not be gifted with a similarly inept adversary for some long time.) Because a very small number – potentially just one – nuclear weapon exploded at high altitude over an American expeditionary force attempting forced entry against a major regional power could potentially tip the balance against our efforts, all such powers who contemplate someday possibly confronting us will be incentivized to develop, acquire or retain nuclear weaponry – quite contrary to the goals of ongoing nuclear nonproliferation efforts and to the objectives of the Revolution in Military Affairs. It might be noted in this context that there are over 10,000 ballistic missiles presently owned by over 30 countries which are potentially capable of lofting a nuclear weapon to high altitudes over proximate U.S. forces – and that none of the ballistic missile defense programs of the current Administration aim at military "products" which could defend against such "pre-apogee" nuclear EMP attacks thrown by ballistic missiles against U.S. forces.

Either as a demonstration-of-military capability or a show-of-national resolve, exploding a nuclear weapon continues to have no peer. (The South African example naturally comes to mind in the current context, both with respect to its motivations and its successful covertness.) If exploded so as to also cripple opposing military forces without also inflicting mass casualties, the potential attractiveness of such weaponry likely becomes quite compelling. A few nuclear weapons and unstoppable delivery systems (e.g., attacking ballistic missiles facing only Clintonesque missile defenses) which can throw them into space, one at a time, over an invader's forces thus naturally rise to the top of the "wish list" of many types

of national leader. North Korean options of these types relative to American forces deployed in South Korea and Japan come unbidden to mind.

The ability of North Korea to attack the continental United States in the very near term with small nuclear weapons thrown with advanced variants of the current Taepo Dong missiles is by now well-known to the Washington national security community, thanks in large part to the efforts of the Rumsfeld Commission

Thus, for several reasons, each one good-and-sufficient, the U.S. would be well-advised to manifest far more effective concern than prevails at present regarding EMP attacks against its national territory and against its forces abroad. Conventional approaches to threat assessment – i.e., those which typically quite conservatively-and-conventionally assess both the capability and the intent of potential adversaries – may result in Pearl Harbor-class catastrophes in the context of EMP attacks.

EMP ISSUES FACING THE DEFENSE DEPARTMENT. Against such current and anticipated-future geopolitical backgrounds, then, what are the major EMP-related issue-sets facing the DoD?

First, having incompletely triumphed in its EMP hardening efforts during the Cold War – when the threat was clear-and-present and the resources were relatively plentiful – how can credible DoD responses to present and emerging EMP challenges be rationally anticipated now? Specifically, how would a reasonable skeptic be persuaded of the seriousness and effectiveness of any new-found DoD sense-of-purpose with respect to EMP defenses?

Second, how can DoD reliably eliminate the prospect of a single nuclear explosion occurring at high altitude over the U.S.? (Indeed, how can it detect that such an EMP attack is underway, or that it is likely?) How can it robustly attribute the origin of such an attack, noting that at least Russia, China and India manifestly have the capability to execute such an attack today, and that North Korea – a nation with which the United States is still nominally at war – may gain such capability within a time-frame of months? If reliable defense is not feasible and robust attribution-for-deterrence is not possible, how is eventual attack to be rationally judged to be at all unlikely?

Third, how much is DoD willing to carve out of its present-day, still-shrinking-in-real-terms budget to defend itself and (a clearly independent issue) to defend its Nation-sponsor from EMP attacks? Where, in particular, is how much money going to come from? How is this amount to be seen as credible, relative to what level of EMP defensive/hardening requirements? This issue-set is posed against the background of the current small-scale internecine strife within DoD between the "EMP Establishment" and a small but well-positioned set of heretics seemingly bent on minimizing the possible magnitude and significance of EMP from any-and-all national perspectives.

Fundamentally, DoD must decide that it is significantly more important to engage the EMP issue now that it was a decade or two ago, or no intra-Departmental initiative is possible in the current budgetary environment. The (non-)emphasis given EMP issues in the most recent QDR and in the even more recently concluded White House-commissioned study of infrastructure durability-under-attack seem diagnostic.

DoD must then learn the lessons of how-and-why it succeeded in some EMP defensive programs and more-or-less failed in many others, over the past three decades. (The associated large-scale scrapping of pleasant fairy tales and reversion to full candor necessary for such self-education in this area may be possible only because so much time has elapsed since most such programs culminated.)

Then resources adequate to the EMP defensive tasks must be identified and robustly fenced, and a single, highly-capable, long-term-accountable, senior-level-reporting individual given responsibility for all aspects of program execution, from start to finish. Only under such circumstances is it realistic to rationally expect real progress.

Finally, the Department would be well-advised to lead from its few positions-of-relative strength among its myriad components. Notable among these in the EMP context are STRATCOM, the Defense Special Weapons Agency (DSWA) operation recently merged into DTRA, and the Army's Nuclear and Chemical Agency.

At the bottom line, however, it's difficult to be optimistic regarding a much- improved DoD posture on EMP. Indeed, quite the opposite seems to be the odds-on bet.

EMP ISSUES FACING THE CONGRESS. With all due respect, the only fundamental issue facing the Congress is determining the degree of its own concern regarding the EMP threat to National military capabilities and to the at-risk portions of the Nation's infrastructure.

Once the degree of this concern is determined, the Congress may then ascertain quite readily whether or not it is sufficient to elicit a voluntary, "If you want it done, we're willing to do it" response from the DoD. If it isn't, then the only remaining question is whether the Congress is minded to mandate in statute the desired response from an unwilling DoD – with all the well-known risk, cost and subsequent oversight hassles thereto pertaining – very notably, with respect to infrastructure defenses, which are not Federally owned.

It's of fundamental importance for all such Congressional consideration to realize that the ways-and-means for defending against EMP threats are far more readily available, less expensive and more effective today than they were even a decade ago. This nearly-qualitative change in EMP-defensive capabilities has arisen as a direct consequence of the proliferation of very high-performance electronics throughout American civilization, i.e., personal computers and telecommunications devices. An unavoidable consequence of the ever-higher performance of these devices is that they continuously generate very low-level EMP-like signals; also, due to their very small size, they are exceptionally sensitive to interference in their operations from EMP-like signals.

These considerations have motivated manufacturers of these systems to provide passive defensive means against interference with their normal operation by EMP-like signals coming from outside of them; also, the manufacturers, on their own and due to Government regulations, have constructed these systems so that they emit very little of the EMP-like signals which they generate in normal operation. Together, these passive defenses not only make a substantial fraction – indeed, the most modern fraction – of the American infrastructure more robust against EMP threats, but they also provide the ways-and-means, both technological and intellectual, for extending this relative robustness into many other EMP-vulnerable portions of our Nation's electrical and electronic infrastructure – both its military and civilian components.

These defenses have two basic forms. The first consists of enclosing electronics in high-integrity metallic shells, since even quite thin layers of metal essentially completely stop both the most threatening aspects of EMP and the low-level electromagnetic interference resulting from high-performance equipment operation. The second defensive step consists of simple, very low-cost means for suppressing electrical surges on consumer-level electrical power and signal lines, so that feeding electrical power to equipment or connecting telephone or cable signals into it don't also provide pathways for ruinous EMP to damage or destroy its circuitry.

The fundamental reason that significant portions of the American infrastructure are much more robust today than a decade ago against EMP threats is simply due to the now-pervasive use of these two technology-sets in the modern portions of the computing and telecommunications plants of the United States. This constitutes an applicable track and an excellent example for enhancing the robustness of much of the currently unprotected infrastructure of our country, military and civilian.

RECOMMENDATIONS FOR CONGRESSIONAL CONSIDERATION. If the Congress chooses to initiate an EMP defensive program, I respectfully recommend that any such initiative include the following features:

Mandated Organization-For-Success. A brand-new, single-purpose organization is a political luxury in DoD, but it is a time-proven "high road" to programmatic success. If order to be maximally effective, such an organization must be run by a highly competent, surpassingly dedicated "benevolent dictator" whose enjoys unquestioned tenure and direct reporting to top-level DoD officials. (E.g., the House's FY'98 Defense Authorization Bill mandated such a reporting line for the Director of BMDO).

The government staff of this organization must be exceedingly few in number, exceptional in professional preparation and highly empowered. Industrial collaborators must be carefully selected for across-the-board competence, trusted and empowered thereafter and without exception – and likely compensated on a CPFF basis. External meddling in organizational business must be sharply minimized, and programmatic turbulence of all types – particularly with respect to budget and "mission creep" – rigorously suppressed.

DoD doesn't create many of these operations, for reasons both regrettable and obvious; if the Congress really wants EMP defensive programmatic success, it'll mandate such an operation into existence. (All of these are features identified in a fairly recent RAND study of the F-117 Stealth fighter program to be common to those DoD acquisition programs that perform in peacetime as well as the really crucial ones usually do in wartime.)

Mandated Across-The-Board Competition. All routes to programmatic success must be fairly and objectively evaluated, and defensive hardware from all vendors evaluated objectively on a common basis. Insisting on "picking winners and losers" is a regrettably common way for ego-blinded DoD program managers to fail. Mandating such pervasive competitive arrangements is the only reliable way to gain them.

Assured Managerial Accountability and Stability. Most DoD acquisition programs perform as abysmally as they do, relative to the closely comparable people-sets working in American industry, primarily because managerial stability is distinguished by its absence and managerial accountability is correspondingly non-existent. "State property is nobody's property" as the old Soviet saying went, and the U.S. Government's proprietary interest in programmatic success of its Defense acquisition programs is almost invariably "co-owned" by precisely no one, civilian or military. Even a superficial comparison of Soviet and American experience over the past few decades indicates clearly that, without some type of proprietorship, no "property" will be decently looked after, and the long-term consequences likely will be telling ones. The Congress would be well-advised to act accordingly with respect to creation of EMP defenses: the program's senior managers should be "lashed to the mast" until the programmatic ship weathers the inevitable storms.

Design-To-Cost Focus. One pervasive problem encountered in the DASA/DNA/DSWA/DTRA EMP hardening program was a single JCS specification for EMP hardness which had to be met by specified construction techniques, no matter what the attendant cost or difficulty might be for particular military systems. While the hardness level had a quite fundamental and rational basis, it might be more appropriate under prevailing circumstances to mandate hardening to a performance, rather than a construction, specification-set and to design hardening to a specified, not-to-exceed total cost-per-system hardened. Congressional cost caps of undoubted robustness wonderfully concentrate both the bureaucratic and the defense-industrial minds – particularly if contractor profits-and-fees are specified-in-advance to be paid out the wrap-up portion of the program's capped total budget.

"Free Fixes" Arrangements With DTRA Customers. One of the standard ways-to-crash in the DASA/DNA hardening program arose from the fact that the agency's folks were chartered to provide all manner of free assessment, advice and technical consulting to the military customer, but the customer had to pay all of the actual costs of hardening his own systems. As a consequence, only the unusually rich or the exceptionally diligent customer ever managed to pay for more than a small fraction of the hardening work to be done. An obvious fix for this fatal hesitation is to subsidize – perhaps even completely – EMP hardening work, and maybe even offer incentives to sign up for hardening. Again, cost caps on 'fixes' – perhaps supplemented by fee incentives for on-spec/under-budget performance – may serve usefully to keep overall program budgets on-track.

Independent Periodic Assessments. For nearly three thousand years, the applicable maxim of Western jurisprudence has been "No man is an apt judge of his own cause." Particularly in its oversight of any Congressional initiative – one in which DoD co-ownership might be somewhat lacking – the Congress would be well-advised to commission independent reviews and assessments of programmatic progress made and problems encountered. No honest program will object to a single swiftly-executed annual review by competent-and-objective folks who can be "brought up to speed" without undue effort or delay. DoD's own Operational Testing Office might serve quite usefully in this capacity.

Frequent Full-Up Trials Of Prototypes. Those DASA/DNA/DSWA EMP hardening programs which were more likely to be successful had frequent testing of hardened sub-systems and systems as a major feature. Such exercises build confidence that progress is being made while also uncovering problems when they're small and relatively quick-and-cheap to fix. They're not diversionary, and should be mandated if simple encouragement to do so is insufficient.

It is notable in this context that the system-level EMP hardness of most all American space assets currently is entirely conjectural, due to a pervasive lack of realistic full-up testing in recent years; any assertions to the contrary can be most charitably characterized as white lies. That a National capability to conduct realistic full-up system-level testing of critical space assets was developed and exercised so tellingly – and then abandoned – is a major "blot on the copybook" of several recent OSD senior management crews with respect to safeguarding crucial features of the National interest. A clear and firm Congressional mandate is the only "sure cure" for this problem.

Credible Performance Certifications. Several large-and-venerable investment houses have sustained titanic losses in the past few years by allowing their high-rolling traders to run their own back-offices, with the result that losses were effectively concealed until they ran into ten figures. Government programs that are allowed to monitor, review and appraise their own performance often run into similar difficulties – with the notable difference that these failures are typically entombed discreetly in classified document repositories. Certification of EMP hardness of various military and civilian systems in transparently-operated all-DoD test facilities is a sine qua non for programmatic integrity.

Mandated Balance Between Military- And Civilian-Directed Efforts. Encouragement by the Government of civilian builders and operators of EMP-vulnerable components and systems should be pervasively encouraged – using all necessary means – to design, build and operate EMP hardness into their systems. These means may range from building to GSA-issued EMP standards in order to provide equipment to any Government agency to GFE-type testing and certification of industrial equipments offered to the commercial market, akin to a UL seal-of-approval, and may include mandates to federal regulatory agencies, e.g., the FCC, which supervise and license EMP-vulnerable national infrastructure. In any case, the Congress should periodically re-visit and, as necessary, re-tool statutory language aimed at balanced hardening efforts in the military and civilian sectors, so that national security "front-doors" are not locked while "back-doors" are left wide open. It obviously makes no sense to gain an EMP-robust military machine while the National civilian electrical/electronic infrastructure remains tissue-soft.

Obvious features of hardening of civilian infrastructure will surely include regularly hardness-tested "backbone" systems, e.g., for essential communication functions, and regularly exercised rapid-reconstitution ways-and-means, e.g., for restoring large-scale electrical power systems from hardened, distributed component stores. While largely civilian-sector in character, assuring that such minimum essential capabilities either reliably survive EMP attack or can be quickly re-constituted thereafter surely falls well within the Congressional ambit of ". . .providing for the common defense".

Continuing Congressional Engagement. Accompanying all of the above is a need for continuing Congressional engagement with the DoD's best thinking and analysis, of the general character which is traditionally associated with Congressional oversight proceedings which review mandated annual reporting and ad hoc certifications. Indeed, and again with all due respect, the Congressional follow-up with respect to the existing statutory demand on the SecDef and the DCI for an EMP posture statement will be prognostic.

Congressional oversight with which I'm familiar in the strategic warfare area has been highly commendable in its peak intensity, its intellectual acumen and its cogency but, again with all due respect, has been less-than-perfect in its regularity and follow-through. Constancy and perseverance will be crucial in seeing Congressional mandates faithfully and efficiently translated into DoD programs and EMP defenses-in-being, as cognizant Government officials-and-officers come and go with remarkably high frequency. Commitment of highly capable, single-task Congressional staff members to such functions would have both symbolic and practical significance.

CONCLUSIONS. Electromagnetic pulse (EMP) is a "weapon of mass hardware destruction", even one instance of which could cripple much of the U.S. military machine and which also can lay waste to modern American civilization – without directly harming a single American. Technical means of defense against EMP exist which are of unquestioned technical feasibility and military effectiveness. Whether EMP defenses are financially and programmatically feasible to produce and deploy is for the Congress to determine – for corporate DoD seems to have elected to mostly turn its face from this esoteric but possibly historic issue.

I thank the Committee once again for this opportunity to appear and comment on these matters of enduring significance for our Nation's security.

Information Submitted In Compliance With

Rule XI, Clause 2(g) of the House of Representatives

Dr. Lowell Wood is a Visiting Fellow at the Hoover Institution on War, Revolution and Peace at Stanford University, and a permanent staff member (currently on the Director's Technical Staff) of the Lawrence Livermore National Laboratory, operated under long-term contract (since 1953 through the present) by the University of California for the U.S. Department of Energy and its predecessor organizations, under Contract W-7405-eng-48.

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Dr. Wood is not representing the Hoover Institution or the Livermore Laboratory, or presenting positions of either of these organizations, in the course of his appearance before the Subcommittee. (To the best of his knowledge, neither of these organizations maintains any positions on any of the subject matter of his testimony.)

Neither the Hoover Institution nor the Lawrence Livermore National Laboratory have contributed to the preparation of his testimony, which has been prepared by him as a private individual. Dr. Wood's testimony is offered as being solely his own, not necessarily representing the opinion of anyone – or anything – else.