NAVAL WAR COLLEGE
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STREETFIGHTER, THEATER MISSILE DEFENSE, AND SPACE BLOCKADE, A MARRIAGE MADE FOR THE HEAVENS.

by

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A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

The comments of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Navy.

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Abstract

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If you would have peace, prepare for war.

--Benjamin Franklin

INTRODUCTION

This paper will address the increasing likelihood of an attack in the form of a high-altitude nuclear detonation. It will address orbital dynamics and nuclear phenomenology, our vulnerabilities to such effects, the probable impact on our satellite assets, military forces, and civil infrastructure and preventative radiation hardening methods.[1] Also presented are the expanding threat from the proliferation of missiles and nuclear weapons,[2] collaborations of "rogue" States and terrorist groups and the resultant growing potential for nuclear terrorism.[3] This paper will discuss a hypothetical North Korea scenario to highlight regional attack potentials, and will also proffer an historical comparison of the impact of new technology and its penchant to increase both critical strengths and critical vulnerabilities. Last, as a small portion of what must be a significantly more encompassing ultimate solution, a suggestion will be made for the structuring of Naval TMD assets to obtain the utmost defensive counterair capability against high-altitude nuclear attack.[4]

The United States and her allies are increasingly more reliant on the use of technologically advanced systems for the attainment of both military and economic goals.[5] Many of these systems are physically located on-orbit, are dependent upon on-orbit assets for normal operation, or are assets that are susceptible to the effects of a high-altitude nuclear burst.[6]

Due to its dominant military posture, the United States is relatively unassailable to conventional/symmetrical attacks.[7] Therefore, as the United States continues to exert its influence in the world, States and organizations in opposition to American goals will increasingly be driven to asymmetric means of attack.[8] Evidence of such asymmetric tendencies can readily be found in the 1993 terrorist bombing attack on the United Nations Building in New York,[9] the 1998 terrorist bombings of our embassies in Africa,[10] and in the recent infiltration attempts of our nation's borders.[11]

Despite best efforts, the proliferation of both nuclear and missile technology is ongoing and seemingly inevitable.[12] A State or organization opposed to the U.S will eventually obtain the capability to launch and detonate a nuclear device at high altitude.[13]

> *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 [sic] 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 should 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.)[14] (Original emphasis)

A nuclear detonation at high-altitude potentially would affect our space-based assets and would additionally have significant effects on ground assets over a large area. Thus, when this capability is obtained, the mere threat of such use may influence the policy and actions of space-capable nations, and will have especial credibility against the most technologically advanced nations.[15]

Orbital Dynamics, Low Earth Orbit, and the Van Allen Belts

Low Earth Orbit (LEO) is an ideal location for surveillance and communication satellites. LEO provides enough height for a relatively stable orbit, while being low enough to allow for the best possible imaging results and minimum communications lag. Objects on LEO orbit the earth roughly every 90-150 minutes,[16] share the physical constraint of crossing the equatorial plane twice per orbit,[17] and are still "low-enough" to be somewhat protected from solar radiation by the earth's magnetic field.[18] Our commercial satellite industry's reliance on this protection means that our LEO satellites are the most vulnerable of all:

> Worst scenarios involve high-altitude, low-latitude . . . bursts, even at low . . . yields. Here, low earth orbit satellites (at altitudes less than about 1000km)-which, in the natural environment, see the lowest natural threat and therefore receive the least hardening-can be subjected to high levels of total dose radiation that can last for months and even years and affect the satellites' useful lifetimes.[19]

The Van Allen radiation belts are "two layers of intense ionizing radiation that surround the earth in its outer atmosphere."[20] High-altitude nuclear detonations stimulate both Van Allen belts to emit much greater levels of ionizing activity,[21] but there are key distinctions to be made between them. While both Van Allen belts are affected by nuclear bursts, the upper Van Allen belt is stimulated for a relatively short duration measured in days or weeks, resulting in a smaller increase in the total ionizing dose.[22] The lower Van Allen belt is excited for much longer periods measured in months or years, resulting in a more significant increase in the total ionizing dose.[23]

The latitude of the detonation determines which belt will be primarily stimulated.[24] The lower Van Allen belt is affected by low-latitude nuclear detonations while the upper Van Allen belt is affected by high-latitude bursts.[25] In like manner, the lower Van Allen belt impacts upon objects on LEO while the upper belt affects objects in higher orbits.[26]

From this we determine that a high-altitude high-latitude nuclear detonation would have a relatively lesser impact on "earth-shadowed" geosynchronous satellite systems. Since these systems operate in the harsher realm of higher orbit and are less protected by the earth's magnetic field, they are necessarily constructed to be able to survive a higher total ionizing dose.[27]

Thus, a State or organization desiring to create the greatest effect on our satellite systems would desire to detonate nuclear device in a high-altitude low-latitude location. Nuclear detonation in such a location will result in the greatest increase in total ionizing dose, and this dose will be absorbed by the LEO satellites; the very systems most susceptible to damage.[28]

Nuclear Phenomenology

For the purpose of this thesis, militarily significant phenomenon are classified as prompt or delayed.[29] Prompt phenomenon are:

Electromagnetic Pulse (EMP). All nuclear explosions generate an EMP over LOS. However, with ground or low-altitude nuclear bursts, EMP is relatively immaterial compared to the direct damage caused by blast and thermal effects.[30] However, at higher altitudes the situation is reversed and the EMP has more impact on ground targets than blast and thermal results.[31]

A rough understanding of EMP formation can be garnered from recent congressional testimony:

> When the detonation occurs at . . . greater than about 40 kilometers, the gamma rays . . . encounter the atmosphere . . . interact with air molecules to produce positive ions and recoil electrons. . . .The Earth's magnetic field interacts with the . . . electrons and causes charge acceleration, which further radiates electromagnetic energy. EMP is produced by these charge separation and charge acceleration phenomena, which occur in the atmosphere in a layer about 20 kilometers thick and about 30 kilometers above the Earth's surface.[32]

System Generated Electromagnetic Pulse (SGEMP). EMP can only occur within the atmosphere. However, satellites within line of sight (LOS) of the detonation are still quite vulnerable to immediate effects because of SGEMP. SGEMP occurs when gamma and x-rays affect a satellite by releasing electrons which can "produce spurious currents that can cause upset or burnout of these systems."[33]

Delayed phenomenon are less intuitive as they are not restricted to LOS considerations, yet they produce significant military impact on satellites and communications capabilities. In addition to the previously discussed stimulation of the Van Allen belts, some delayed phenomenon are:

Beta Decay. After detonation, all nuclear debris does not fall to earth. Much will remain on-orbit where:

> Weapon debris carries a significant percentage of the energy of the detonation and this radioactive material releases enormous numbers of high-energy electrons through beta decay. This phenomenon creates an artificial "trapped electron" radiation belt. The energies of the . . . electrons are significantly higher than the natural environment [and] . . . can dramatically shorten the lifetime of satellite systems.[34]

As surviving LEO satellites orbit, they pass through the ionizing effects of the debris. Satellites absorb more damage with each pass. "Projected lifetimes of up to ten years can be reduced to a mere two months after such an event"[35]

Ionization. A high altitude nuclear detonation will produce radiation that will directly react with the upper atmosphere. The ionization that will result will block high frequency radio communications for hours or days. This effect could be similar to the impact we experience during significant periods of sunspot activity.[36]

Vulnerability

The U.S. tested relatively small nuclear devices at high-altitude in 1958's Operation Argus,[37] and a larger device in 1962's Operation Starfish Prime.[38] Based on both the 1958 and 1962 test results, we know that the detonation of a nuclear burst at high altitude will generate a militarily significant impact on space and ground-based assets.[39]

A high-altitude nuclear detonation will produce an EMP that could result in the loss of unprotected air and ground-based assets.[40] Specifically, an EMP will immediately damage today's highly vulnerable low-voltage computer systems.[41] Tomorrow's faster, lower-voltage systems, the modern basis for both our commerce and military prowess, will be correspondingly even more vulnerable.[42]

Additionally, a high-altitude nuclear detonation will generate a SGEMP which could immediately affect LOS space-based assets while unhardened satellites shielded by the earth's mass will gradually be destroyed by enhanced ionizing radiation."[43] In a similar vein, reconstitution of satellite assets will be more difficult due to the lingering effects of ionizing radiation. Moreover, upon such a detonation, fallback high frequency radio assets will be unusable due to atmospheric ionization.[44]

Operation Starfish Prime was a 1.4-megaton high-altitude thermonuclear test over Johnston Island in the Pacific Ocean.[45] It reportedly generated significant EMP effects nearly one thousand miles away in Hawaii as cars stalled, telephone systems burnt out, and radio stations went off the air.[46] Higher-altitude bursts would have a correspondingly larger line-of-sight impact. "A nuclear burst at 500 kilometers in altitude can cover the entire continental United States."[47]

Recall that the Starfish Prime took place in 1962, well before the advent of information age technology. As computer systems have developed, they have become more sensitive to smaller voltages.[48] As technology continues to advance, this sensitivity becomes more pronounced.[49]

> The integrated circuit density that we see at the present time is nearly a factor of 10,000 greater than it was just a quarter century ago, and that basically says that the vulnerability of the individual devices have increased correspondingly. There is reason to believe that the semiconductor-based portions of our communication

system, which is to say essentially all of it, would be extremely EMP vulnerable. Measurements done on individual systems certainly support that projection.[50]

Pervading our society, microchip usage now ranges from the more obvious applications in computers, automobiles, and cellphones, to less apparent items as represented by washing machines, microwaves, and children's toys. A noted expert, Doctor Lowell Wood of Lawrence Livermore National Laboratory sums up our civilian vulnerability: "Even a modest, single-explosion EMP attack on the U.S. would likely devastate us as a modern, post-industrial nation."[51]

Hardening

If we are so vulnerable, what then is involved in providing protection for our assets? Certain United States military assets are hardened but many are not. [52] This is in part due to the increased cost involved in hardening and partly due to the military's commercial-off-the-shelf purchasing initiatives.[53] Both commercially available computer equipment and commercial satellites are almost never hardened as competition pressures drive the requirement to keep systems as affordable as possible.[54] Hardening can be directed against EMP/SGEMP, ionizing radiation or both.[55]

While satellite systems are hardened to survive the hostile environment of space, most are not hardened to survive enhanced ionizing radiation.[56] Hardening is possible for all systems but is unlikely without specific mandates.[57]

For packaged or "in-transit" equipment, EMP protection can consist of a thin, unbroken metal shell around an unused system.[58] However, for systems in use, more practical EMP shielding can be roughly equated to a surge arrester on a home computer.[59]

The commercially available surge arrester is designed to be effective when operating against power spikes akin to those resulting from a nearby lighting strike."[60]

Typically, the rise time of a lightning strike is in the neighborhood of one to two microseconds. The commercial arrestor, in order to be cost effective, is specifically designed to provide protection in this timeframe. At five nanoseconds, an EMP/SGEMP produces a rise time that is two orders of magnitude faster than that imposed by a lightning strike.[61] Thus, our civilian infrastructure is vulnerable, as commercial arrestors are unlikely to provide EMP/SGEMP hardening.

An EMP can be produced by many sources that can cause failures in items ranging from cars to major power plants.[62] As a result automakers routinely subject their most advanced concept cars to EMP generators at White Sands Missile Range.[63]

Unfortunately, automakers are not the only people aware of EMP dangers. Military writers at the Chinese War Colleges are openly planning on employing high-altitude nuclear detonations to exploit this critical vulnerability.[64]

<u>Proliferation</u>

As seen just this past year in a highly publicized scandal, China allegedly stole significant missile technology from the U.S.[65] Even a casual glance at today's world scene shows a flurry of proliferation.[66] According to the Washington Post, "the CIA has identified the main weapons proliferators as Russia, China, and North Korea. . . . In the future, Iran, Pakistan, Libya, and Syria are expected to join in."[67] A reason for concern here is that missile and nuclear weapons proliferation can exist in a synergistic relationship. After all, both require significant levels of technology and States so involved may share common goals such as regional dominance or anti-western sentiment.

An example of just such a relationship is that between North Korea, Congo, and Iran. According to one report, Iran is employing North Korean technology to produce

Scud Missiles that it sells to Congo, then (possibly in exchange for uranium ore) Congo's military receives training by North Korean military advisors.[68]

More with Less

As the U.S. military services continue their evolution towards network centric systems and methods , a force is being created that, though smaller in number, is more able to inflict precise and coordinated effects.[69] This is arguably America's critical strength.

The evolution towards network centric methods is greatly increasing the usage of systems that are computer based and bandwidth dependent. Today, 95 percent of our military communications go through commercial channels.[70] It is apparent that this bandwidth requirement will increasingly outstrip the capacity of our limited hardened military satellite systems. Thus, the increased lethality of massed effects is becoming more dependent upon communications that are often routed through vulnerable commercial satellites.[71] This is America's critical vulnerability.

A Hypothetical

The Honorable Curt Weldon, posed the following:

> If I am the commander of North Korea and I have one nuclear weapon . . . in the range of 1 to 10 kilotons, which I assume it is, and if I have the capability of a Nodong or Taepodong 2, system which I can assume can reach an altitude of 250 miles quite easily . . . and I want to do something to hurt the United States, I think the weapon of choice is to launch that device in the air and wipe out our smart capability . . . [72]

If North Korea were to invade the South, the U.S. would likely respond with a massive positioning of forces in the region. North Korea would not violate international law if it were then to explode a nuclear device over its own territory.[73] Undoubtedly, significant disruption would be experienced in American and South Korean forces as trucks, planes, computers, and other unprotected assets would fail.

North Korea would experience ill effects also and one could argue that the very impact of EMP would prevent its employment. But in this scenario, the more numerous North Korean core assets of artillery, small arms, and soldiers would remain viable threats. In fact they would enjoy the boon of the elimination of the American forces' critical strength as the vastly outnumbered U.S. forces would be essentially reduced to World War II-like abilities.[74]

In advance of the nuclear detonation, North Korea would know when to shield critical items like cell phones and power generation capabilities. In the post EMP region, North Korea might actually have better tactical communications than their outnumbered American and South Korean opponents. The result could well be a significant regional shift in power. The U.S. could find itself unable to project power with accustomed network centric effectiveness. The U.S. could be faced with the equally unpalatable dilemma of either accepting massive casualties while employing industrial-age weapons and tactics, abandoning our South Korean allies and eroding our "superpower" title, or falling back upon our nuclear supremacy.

Attack Probabilities

The Center for Naval Analysis conducted a study of the most likely forms of Anti-Satellite attack we could expect against our Space-Based assets. Among many others, three factors examined in the analysis were the likelihood of a particular form of attack; the potential damage resulting from such an occurrence; and the ability of the State conducting the attack to remain undetected. In the study, direct attacks against on-orbit assets were considered a remote probability since detection was deemed highly likely.[75] Given detection, the U.S. would presumably respond with diplomatic and military initiatives.[76] The study made the assumption that the opposed State (or organization), would act in a "rational" manner. The United States Space Command appears to share this belief, stating in the Long Range Plan, "Nation states probably wouldn't be willing to accept fratricide of satellite systems".[77]

Terrorist Organizations

Officers are trained to focus on enemy capabilities rather than intentions and we forget this lesson at our peril. A rogue State's behavior may be quite rational within its culture. As unfathomable as it may be, many cultures and organizations do not approach world issues with the same basis of rational calculus as does the U. S.

As the bombing of the Marine Barracks in Beirut and similar attacks elsewhere indicate, terrorist organizations are capable of horrific yet militarily effective acts. As technology continues to proliferate,[78] due to simple supply and demand and a concomitance of interests with rogue nations,[79] terrorist organizations may gain access to both nuclear and TBM capabilities.

An example of a state "protected" terrorist and, from an American perspective, a non-rational calculus is the Taliban's interactions with Osama Bin Laden and his organization.[80] In a more extreme case, according to the New York Times the Pakistani government, in an effort to strike clandestinely, employed the terrorist group Harkat ul-Mujahedeen to conduct the hijacking of an Air India Jetliner.[81] Yet another is the cult of Aum Shinriko. Famous for the Tokyo Subway nerve gas attack and numerous "VX" nerve agent assassinations,[82] until recently, the powerful organization numbered its membership in the tens of thousands and is believed to have had assets of one billion dollars.

Ambitious, the Aum Shinriko aggressively recruited scientists and reportedly attempted to extract uranium from an Australia Sheep Farm. When interviewed shortly after the Tokyo Subway attack, the Aum Shinriko spokesperson explained their motivation by holding up a copy of Isaac Asimov's famous Foundation Trilogy. The trilogy's central theme consists of the inevitable collapse of a galactic civilization and its' ultimate reconstruction. Aum Shinriko advocates hastening the "unavoidable" collapse of world civilization in order more to rapidly generate world reconstruction.[83] Seemingly nothing would prevent such an organization taking advantage of proliferation to obtain a technologically advanced capability and then using it as a viable means to disrupt the United State's influence. With groups like Aum Shinriko willing to shoulder the responsibility, it becomes conceivable that an opposed State might readily assist in such proliferation.

Counterair Concepts

The counterair framework includes both offensive and defensive counterair. Offensive counterair includes attacks on enemy missile sites prior to launch. Defensive counter air consists of active air defensive and passive air defense. Active air defense is "direct defensive action to destroy . . . hostile air and missile threats . . . "[84] Passive air defense consists of camouflage and deception, hardening, reconstitution, NBC facilities, detection and warning, and dispersal.[85] In the interest of space, this paper will focus on an active air defense employment of Naval TMD systems.

Naval TMD Systems

The naval systems we are currently developing are projected to consist of a lower and upper "tier". "The lower tier system, Navy Area TBMD, will be provided by the SM2 Block IVA interceptor."[86] Designed to engage in active defense against a descent-phase ballistic missile, this system is intended to conduct engagements in atmosphere. Depending on the range of the attacking TBM system, lower tier systems can defend a relatively small footprint of roughly 65km to 120km.[87] Thus, lower tier defenses will require a relatively large quantity of missile platforms. Since the SPY radar system can sense well outside these footprints,[88] a similarly large number of radar systems are not necessarily required.

The upper tier system is the Navy Theatre Wide (NTW). This system will have an ascent-phase (but not boost-phase) engagement capability and can engage missiles (only) above the atmosphere. Because it can engage so early in a ballistic missile's flight, it has the ability to defend a much wider area than the "point defense" oriented Navy Area TBMD and thus, for this mission, only a relatively small number of missile platforms are required.[89]

Cueing

For effective employment, both tiers will perform best with outside cueing. In the future, the soon-to-be-fielded Space Based Infrared (SBIR) satellites, under the direction of U.S. Space Command, will provide this outside cueing by detecting the infrared signature of missiles in boost phase.[90] By 2008, Aegis systems are expected to directly receive cueing from the SBIR's constellation.[91] With or without such cueing, targeting and engagement data can be provided by the Aegis' SPY radar systems. The Aegis radar systems can cue each other, as they will be linked together by the Cooperative Engagement Concept, which will provide all linked military assets a Single Integrated Air Picture.[92]

The Impact of Success

In constructing our TMD assets, we are successfully removing yet another means that an opposed State or terrorist organization will be able to attack the U.S. and our allies. While this is assuredly a good thing, will this drive the opposed State or terrorist organization, or some difficult to identify, track, and prove coalition of the two, to strike in an unexpected or asymmetric manner?

Assume the future brings reasonable success on the part of U.S. Theater Missile Defense (TMD) systems. Frustrated by our deterrence of his TBM arsenal weapons against point targets, an opponent may find that "engagement geometry" and U.S response times render a high altitude burst not just incredibly effective as an attack option,[93] but due to less opportunities for intercept, the only option liable to succeed.

In terms of response time, our command and control system will likely find defensive counterair operations against a high-altitude nuclear threat as the most challenging of TMD missions. Ascent-mode engagement presupposes the presence of an American TMD asset interposed between the launch site and the target, cued to engage with very minimal reaction time. Ideally, the faster interceptor NTW missile will engage the ballistic missile just as it goes exo-atmospheric. It terms of time and space this mission could well devolve into a modern version of a "tail chase". As Sailors know, a tail chase is a long chase. In the case of ascent-mode ballistic missile intercepts, the tail chase becomes a time and systems critical endeavor requiring presence and diligence.

The ability to obtain the lowest-possible altitude intercept with theater wide depends on many factors including the distance between the two launch sites and the flight path of the ballistic missile. To defend with theater wide TMD while using area wide TMD to defend point targets will require both forward and rearward positioned launch platforms, well evolved ROE and a remarkably responsive command and control network.

Aegis

Aegis cruisers and destroyers are expensive highly capable multi-mission ships.[94] Current plans for Navy TMD systems have the Aegis ships serving as the sole weapons firing platforms. Due to its capabilities, the Aegis is key to the defense of the naval battle group. The Aegis' ability to perform this mission is also directly tied to its placement in relation to the battle group.

To perform the TMD mission, both for area and for theater-wide defense, will require the placement of our Aegis launch platforms within certain positions in relation to the threat area and the defended area.[95] To place one or more of our limited number of Aegis ships in such a constrained launch area may mandate an unacceptable level of risk to the now "less" protected battle group. In addition, if such missions take on a quasi-permanent status, such as the defense of Japan or Taiwan, the requirement could raise the operational tempo of the Aegis community beyond a sustainable level.

Historical Comparison

In 1879 at Isandhlwana, while fighting the Zulu, the British enjoyed the advantage of a relatively new technology, the breech-loading Martini-Henry rifle.[96] With its increased rate of fire, the strength of the British Soldier correspondingly increased.

Unfortunately for the British, they failed to examine what possible vulnerabilities this technological evolution might have on their complete "fighting system". Under the worst possible circumstances, they learned they had failed to adjust their supply organization to provide ammunition rapidly enough to sustain the new technology weapons and, as a result, their fighting system failed and they suffered a crushing defeat.[97]

Similarly, computer and satellite capabilities have greatly increased our nation's ability to project power in a more complementary and coordinated fashion. But as we gradually evolve these capabilities to conduct network centric warfare and we enhance our fighting power through the ability to mass effects, we steadily become more dependent on vulnerable computer and satellite systems.[98] This dependency creates a critical vulnerability that must be protected as the susceptibility of our equipment will only become more pronounced in time.[99]

Have we properly examined our changing vulnerabilities and developed defenses? In the case of the British at Isandhlwana, the increased vulnerability resulted from an inflexible supply organization, oak ammunition chests, large rusty screws, and the "bandwidth" problem of having only one screwdriver per regimental supply train.[100] Our emerging vulnerability seem to be a dependence on bandwidth and intelligence through undefended computer systems and satellites, and a failure to construct a system and doctrine to protect the "high ground" of space. This vulnerability is exacerbated by the proliferation of missile and nuclear technology. To return to my rather worn analogy, What will happen when the Zulu steal the screwdriver?

Remote Sensing of Fissile Materials

How will we know when an opponent is preparing to launch a missile with a nuclear payload? An answer may be found in the many "proliferation detection systems" being developed by at the Lawrence Livermore National Laboratory.[101] These systems vary from advanced gamma-ray sensing techniques with arrays of sensors designed to detect ground-delivered nuclear weapons,[102] hyperspectral infrared imaging spectrometers (HIRIS)[103] and laser-based (LIDAR) systems "to provide detailed spectroscopic analysis of weapons signature materials in waterways, on the ground, and in the air".[104] Advanced data fusion of information from a variety of such sources is also in work.[105]

Streetfighter

Streetfighter is a concept to employ "cheaper" ships for a variety of purposes. These ships are to be capable of multiple roles by accepting various "plug-and-play" packages to perform specific mission requirements. This concept reduces costs as it provides the latitude to employ the same ship for the multiple missions needed in today's world, but at less expense than comparable multiple-mission capable ships. In conjunction with more robust assets, these lower-cost ships can then be configured and employed as force multipliers.[106]

Space Blockade

To defend against the threat of a high-altitude nuclear attack, we will need to embrace a balanced range of defense solutions. One aspect would be the active defense aspect of defensive counterair. Naval TMD systems could well serve as a portion of such a defense. Success at defensive counterair functions will require the joint involvement of all services and support from external intelligence agencies.

For the Naval portion of this "system of systems", I propose to tie the above assets of TMD systems and Streetfighter-type ships to provide additional launch platforms. Streetfighter ships could cheaply address the factor of space while providing enhanced solutions to the "geometry problem" of engaging ascent-phase missiles. These ships could be equipped as upper or lower-tier capable and be positioned to provide greater width or depth to our defensive "firing line".

For lower-tier needs, Streetfighter launch platforms could be positioned near high value assets to provide a defensive capability. Such ships could generate important military and political effects when placed around local critical areas such as ports, airfields, or allied cities. Intelligence sources could employ remote sensing technologies to warn of an impending attack. Upon ballistic missile launch, the TMD launch platforms could be provided engagement and launch guidance by the Aegis systems employing the Cooperative Engagement Concept. These same Aegis systems would be better available to provide for the defense of the naval battle group against other threats.

For upper tier needs, the same or a similar network of such launch-equipped Streetfighter ships would provide more engagement solutions for the upper tier, generating the flexibility to obtain missile kills well before apogee. Such flexibility would directly minimize the threat posed by the ongoing nuclear and missile proliferation.

Conclusion

This paper highlights the need to protect our space and ground-based high-technology commercial and military assets from high-altitude nuclear attack. Our national power, military prowess, and robust economy are largely a result of technological innovation. However, as we continue to evolve toward network centric methods let us recognize that our burgeoning strength may further alienate non-aligned States and organizations and require we protect the growing critical vulnerability that our technologic dependence brings.

Glossary

Active air defense. Direct defensive action taken to destroy, nullify, or reduce the effectiveness of hostile air and missile threats against friendly forces and assets. It includes the use of aircraft, air defense weapons, electronic warfare, and other available weapons. (JP 3-01)

Arrester. A device having a characteristic element consisting of a resistor with a nonlinear volt-ampere characteristic that limits the follow current to a value that the series gap can interrupt. If the arrestor has no series gap, the characteristic element limits the follow current to a magnitude that does not interrupt with the operation of the system. (FEMA, EMP Protection Guidance)

Critical strength. Capabilities considered vital to achieve a given military objective. (Adapted from Naval War College, JMO)

Critical vulnerabilities. Can be critical strengths or weaknesses if they are directly related to the center of gravity and are vulnerable to attack. (Adapted from Naval War College, JMO)

Critical weaknesses. Elements that, while vital, are quantitatively or qualitatively inadequate by themselves to achieve a given or derived objective. (Adapted from Naval War College, JMO)

Defense in depth. The siting of mutually supporting defense positions designed to absorb and progressively weaken attack, prevent initial observations of the whole position by the enemy, and allow the commander to maneuver his reserve. (JP 1-02)

Defensive counterair. All defensive measures designed to detect, identify, intercept, and destroy or negate enemy forces attempting to attack or penetrate the friendly air environment. Also called DCA. (JP 3-01)

Geosynchronous orbit. A direct, circular, low inclination orbit about Earth having a period of 23 hours 56 minutes 4 seconds. A spacecraft in geosynchronous orbit maintains a position above Earth constant in longitude. Normally the orbit is chosen and station keeping procedures are implemented, to constrain the spacecraft's' apparent position so that it hangs motionless above a point on Earth. In this case, the orbit may be called geostationary. (Adapted from www.jpl.nasa.gov)

Hardened. (See Radiation Hardened)

Hardness. The property of an installation, facility, transmission link, or equipment that will prevent an unacceptable level of damage. (FEMA, EMP Protection Guidance)

Ionizing radiation. Damaging radiation that can cause phase shifts in electronic components. (Adapted from FEMA, EMP protection guidance)

Low Earth Orbit. A satellite orbit with an altitude above the earth's surface between 90 and 1000 nautical miles. The upper limit is variable and not clearly defined. (From Naval Space Command instructional CD, An Introduction to Orbital Mechanics)

Network centric warfare. An information superiority-enabled concept of operations that generates increased combat power by networking sensors, decision makers and shooters to achieve shared awareness, increased speed of command, higher tempo of operations, greater lethality, increased survivability, and a degree of self-synchronization. (Alberts, Network Centric Warfare)

Offensive counterair. Offensive operations to destroy, disrupt, or neutralize enemy aircraft, missiles, launch platforms, and their supporting structures and systems both before and after launch, but as close to their source as possible. Offensive counterair operations range throughout enemy territory and are generally conducted at the initiative of friendly forces. These operations include attack operations, fighter sweep, escort, and suppression of enemy air defenses. Also called OCA. (JP 3-01)

Passive air defense. All measures, other than active air defense, taken to minimize the effectiveness of hostile air and missile threats against friendly forces and assets. These measures include camouflage, concealment, deception, dispersion, reconstitution, redundancy, detection and warning systems, and the use of protective construction. (JP 3-01)

Radiation Hardened. DoD satellite systems must be designed to survive much more severe radiation environments induced by hostile actions or high ambient radiation orbits. The specially designed and manufactured electronic components are termed to be radiation hardened. Also called Rad-Hard. (Adapted from congressional testimony)

Rational calculus. A Clauswitzian concept. A reasoned decision to obtain a particular goal.(Adapted from NWC term)

Reconstitution. Consists of extraordinary actions taken by the commander to restore combat-attrited units in the theater to a desired level of combat effectiveness commensurate with mission requirements and availability of resources. This includes cross-leveling or replacing personnel, supplies, and equipment; reestablishing command and control; and conducting essential training. There are two types of reconstitution activities: reorganization and regeneration. (Vego, On Operational Art)

Rise time. The time interval of the leading edge between the instant at which in instantaneous value first reaches the specified lower and upper limits of 10 percent and 90 percent. (FEMA EMP Protection Guidance)

Rules of engagement. Directives issued by competent military authority which delineate the circumstances and limitations under which United States forces will initiate and/or continue combat engagement with other forces encountered. Also called ROE. (JP 1-02)

Total ionizing dose. The maximum amount of radiation a system is designed to withstand. (Adapted from congressional testimony)

NOTES

[1] Jim Oberg, Space Power Theory, (U.S Air Force Academy, CO: March, 1999), 16. Highlights the large economic impact of space activities on the U.S economy. "By 2010, cumulative American investments in space alone will reach $500-$600 billion or about as much as the value of present American investments in Europe. . . . By 2020, the national space industry should be producing 10%-15% of American Gross Domestic Product. It is conservatively estimated that since the beginning of the US space program in the late 1950's, derived technology has added about $2 trillion in present dollars to the American economy. As much as double that figure could be added to the US GDP in the next quarter century."

[2]Joint Chiefs of Staff, Joint Doctrine for Countering Air and Missile Threats (Joint pub 3-01) (Washington, D.C.: October 19, 1999), I-4. "The widespread proliferation of WMD (paired with . . . theater ballistic missiles) greatly increases the importance of employing a robust defense for US forces and assets which impact US national security interests."

[3] Daniel Goure, Air and Space Power in the New Millennium, (Washington D.C.: The Center For Strategic & International Studies, 1997). "Weapons of mass destruction pose and even greater danger in the post-Cold War era. Both ballistic missile technology and various WMD technologies can be acquired by the dedicated organization."

[4]Ibid., GL-3.

[5] Congress, "Threat Posed by Electromagnetic Pulse (EMP) to U.S. Military Systems and Civil Infrastructure," Congressional Record, 16 July 1997, H.N.S.C No. 105-18, 39. "If you had a few . . . nuclear weapons, you probably want to use them in the fashion which imposes the largest damage expectancy on the United States and its military forces. If you are going to go after the military forces and you only have a few, by far and away the most effective way threat you could potentially use it is an EMP laydown. If you were going against the American civilization itself, again, the largest damage you could expect to see by far is that associated with EMP laydown." See also: Ibid., 48. "Today, computers with more and more microcircuits packed into smaller and smaller chips are key to the efficiency of virtually all commerce in the U.S. These have more computing power, bur are also much more sensitive to disruption and more easily disabled by EMP. As our reliance grows, so does our potential vulnerability. Likewise, potential military vulnerability may be growing."

[6] Ibid., 15. "All of these issues become more important as DOD transitions to great dependence upon commercial satellite systems to provide cost-effective and affordable ways of meeting mission requirements." See also: Ibid., 63. Includes graphic of prompt radiation exposure effects upon COTS equipment.

[7] White House, National Security Strategy for a New Century, 1997, quoted in Congress, 8. "Because of our dominance in the conventional military arena, adversaries who challenge the United States are likely to do so using asymmetric means . . . such as WMD . . . "

[8] Ibid.

[9] Associated Press, "Federal jury convicts 10 in UN bombing conspiracy." The Detroit News, 2 October, 1995. http://detnews.com/menu/stories/18525.htm (16 January 2000).

[10] Larry Neumeister, "Suspects in Kenya embassy bombing sent to U.S. for trial." Athens Banner Herald, 28 August 1998. http://www.onlineathens.com/1998/082898/0828.a3bombsuspect.html (16 January 2000).

[11]Scott Allen, "Once Seen as an Easy Target, N.E. Border Goes on Alert." The Boston Globe, 23 December 1999, A1.

[12] "U.S., U.K. Foil Iraqi Bid to Smuggle A-Bomb Parts." Facts On File News Services. 6 April 1990. http://www.2facts.com/stories/index/1990042487.asp (28 December 1999). See also: "Key Issue: Nuclear Weapons." Facts On File News Services. N.d. http://www.2facts.com/stories/index/z00024.htm (28 December 1999). See also: "Chinese Theft of U.S. Nuclear Technology Reported." Facts On File News Services. 11 March 1999. http://www.2facts.com/stories/index/1999128860.asp (28 December 1999).

[13] Stephen Green, "Threat of Electromagnetic War Has Long Worried U.S. Military Leaders."San Diego Union-Tribune, 13 November 1999, 1. "The destructive phenomenon known as an electromagnetic

pulse . . . has worried U.S military leaders ever since. Their concern has heightened as the nation has become more dependent on electronics. . . . The electromagnetic threat has increased with missile proliferation."

[14] Congress, 101. Statement of Dr. Lowell Wood of Lawrence Livermore National Laboratory, a recognized expert on the topic of EMP.

[15] Barry R. Schneider, "Strategies for Coping with Enemy Weapons of Mass Destruction." Airpower Journal. Special Edition 1996, 45-46. "Residual WMD threat might prevent the allies from securing a full victory. . . . Effective active and passive defensives, added to the other elements of a counter proliferation strategy, could make US and allied wartime operations far less risky and more likely to succeed. . . . Failure to prepare for the NBC battlefield is the path to a WMD disaster of epic dimensions that might dwarf other defeats in the history of warfare." See also: National Defense University, Strategic Assessment 1998: Engaging Power for Peace (Washington, 1998), 177-182. "The biggest worry for the United States, as suggested above, may be the indirect strategic effect of a theater peer's behavior in a Eurasian region where the United States has vital interests." See also: Congress, 62. "The value of these satellites, in terms of both replacement cost and the cost of disruption of a major part of our information age infrastructure, is impossible to calculate."

[16] "Space Environment and Orbital Mechanics." U.S Army Training and Indoctrination Command. N.d. http://www-tradoc.army.mil/dcscd/spaceweb/chap5im.htm (28 December 1999) 5.1,5.13.

[17] Ibid.

[18] Ibid., 5.13-5.14. See also: Congress, 65. "Low earth orbit satellites (at altitudes less than 1000km) . . . see the lowest natural threat."

[19] Congress, 64-65.

[20] New Webster's Dictionary and Thesaurus of the English Language. (1993), s.v. "Van Allen radiation belts."

[21] Congress, 64-65.

[22] Ibid.

[23] Ibid.

[24] Ibid.

[25] Ibid.

[26] Ibid.

[27] Ibid.

[28] Ibid., 64. "Perhaps a greater threat to our commercial satellite constellations is that from enhanced trapped radiation that results from nuclear bursts at high altitudes. This is not EMP but is an increase in the total ionizing dose that is encountered by the satellite." See also: Daniel M. Fleetwood, "Total Ionizing Dose Effects on MOS and Bipolar Devices in the Natural Space Radiation Environment." Sandia National Laboratories. N.d. http://mems.sandia.gov/microelectronics/RadEffects/papers/jpl_10_98.html (10 January 2000).

[29] Congress, 63-66.

[30] Ibid., 29. "Well, the effects are always there, except at a ground burst the area of incineration is roughly the same size as the area of EMP laydown."

[31] Jim Landers "A New Kind of Warfare, Fight over Information Has Moved into Cyberspace." The Dallas Morning News, 15 November 1998. 1J. " . . . U.S. information warfare doctrine has to consider what could happen next in such scenarios. A hydrogen bomb exploded 200 miles over the Midwest could knock out U.S. electrical systems that make use of semi-conductors with a giant electromagnetic pulse of energy. There are some nations who might not be able to replicate our information-warfare efforts, but who might find nuclear pulse a very tempting option for evening the score."

[32] Congress, 5. "When the detonation occurs at high altitudes, greater than about 40 kilometers, the gamma rays directed toward the Earth encounter the atmosphere, where they interact with air molecules to produce positive ions and recoil electrons.... The gamma radiation, interacting with the air molecules, produces charge separation as the...electrons are ejected and leave behind the...positive ions. The Earth's magnetic field interacts with the...electrons and causes charge acceleration, which further radiates electromagnetic energy. EMP is produced by these charge separation and charge acceleration phenomena, which occur in the atmosphere in a layer about 20 kilometers thick and about 30 kilometers above the Earth's surface." See also: Ibid., 54-56. For a more in-depth explanation, consult the written testimony of Dr. Gary Smith, Director, Johns Hopkins University Applied Physics Laboratory.

[33] Ibid., 74. The following quote provides a more detailed explanation and is taken from the formal testimony of Dr. George Ullrich, Deputy Director, Defense Special Weapons Agency, DOD. "SGEMP impacts space system electronics in three ways. First, x-rays arriving at the spacecraft skin cause an accumulation of electrons there. The electron charge, which is not uniformly distributed on the skin, causes current to flow on the outside of the system. These currents can penetrate into the interior through various apertures, as well as into and through the solar power transmission system. Secondly, x-rays can also penetrate the skin to produce electrons on the interior walls of the various compartments. The resulting interior electron currents generate cavity electromagnetic fields that induce voltages on the associated electronics which produce spurious currents that can cause upset or burnout of these systems. Finally, x-rays can produce electrons that find their way directly into signal and power cables to cause extraneous cable currents. These currents are also propagated through the satellite wiring harness."

[34] Ibid., 75-76.

[35] Ibid., 76.

[36] "Technical Feasibility of Cessation of Nuclear Testing." Memorandum for the National Security Council. 28 March 1958. http://www.ddrs.psmedia.com/tplweb-gi/fastweb?getdoc+ddrs_img+ddrs_img+1301...:tex (16 December 1999).

[37] "Nuclear Weapons Test Film Descriptions, Operation Argus, 1958." U.S.Department of Energy. http://www.nv.doe.gov/news&pubs/photos&films/0800027/Default.htm (28 December 1999).

[38] "Defense Space Projects Supplement." Department of Defense Report to National Security Council on Status of United States Military Programs as of June 1959. 26 October 1959. http://www.ddrs.psmedia.com/tplweb-cgi/fastweb?getdoc+ddrs_img+ddrs_txt+40002...:tex (16 December 1999).

[39] "Memorandum for the President, Preliminary Results of the ARGUS Experiment." The White House. 3 November 1958. http://www.ddrs.psmedia.com/tplweb-cgi/fastweb?getdoc+ddrs_img+ddrs_txt+46490...:tex (25 January 2000). "A nuclear explosion in space produces three kinds of effects of military importance."

[40] Congress, 30. Discussion of solar radiation combining with the earth's magnetic field to cause "God's EMP", resulting in widespread power outages. "God's EMP [is] . . . very small compared to a megaton burst".

[41] Greg Makoff, The Nuclear Electromagnetic Pulse. Program in Science and Technology for International Security, no. 19 (Cambridge, MA: Massachusetts Institute of Technology, 1988), 14. "Television sets and radio receiver tested in simulators failed in fields as low as 5 to 6 kv/m, and a digital computer was upset when exposed to fields of 1.5v/m. Since theory predicts that most areas of the country will be exposed to electromagnetic fields between 10 and 50 kv/m, these tests indicate that the effects of EMP across our country can be quite large."

[42] Congress, 2. "Today, computers with more and more microcircuits packed into smaller and smaller chips are key to the efficiency of virtually all commerce in the United States. These have more computing power, but are also more sensitive to disruption and more easily disabled by EMP. As our reliance grows, so does our potential vulnerability. . . . 95% of our military communications go through commercial channels." See also: Ibid., 8. "The ability of the EMP to induce potentially damaging voltages and currents in unprotected electronic circuits and components is well-known. The immense footprint of EMP can therefore simultaneously place at risk unhardened military systems, as well as critical infrastructure systems to include power grids, telecommunications networks, transportation systems, banking systems, medical services, civil emergency systems and so forth."

[43] Ibid., 8. "All unhardened satellites in low Earth orbit traversing these enhanced belts can be expected to demise from the total ionizing radiation dose in a matter of days to weeks following one such high-altitude burst" See also: Ibid., 65. "These wide-area features separate high-altitude nuclear detonations from other weapons of mass destruction in the number of systems that are simultaneously placed at risk." (Original emphasis) See also: Fleetwood, 7. "There is a desire to use less costly commercial off-the-shelf (COTS) devices wherever possible in space systems, as opposed to more expensive (or unavailable) radiation-hardened parts."

[44] "Technical Feasibility of Cessation of Nuclear Testing." Memorandum for the National Security Council. 28 March 1958. http://www.ddrs.psmedia.com/tplweb-gi/fastweb?getdoc+ddrs_img+ddrs_img+1301...:tex (16 December 1999).

[45] Congress, 74.

[46] Green. See also: Congress, 9. "The effects of EMP from the starfish event were observed in Hawaii, 1300 kilometers east of the detonation. Street lights and fuses failed on Oahu and telephone service was disrupted on the Island of Kauai."

[47] Ibid., 54-56.

[48] Ibid., 2. "These have more computing power, but are also more sensitive to disruption and more easily disabled by EMP."

[49] Ibid., 94-106. Testimony of Dr. Lowell Wood of Lawrence Livermore National Laboratory.

[50] Ibid., 30-31.

[51] Ibid., 106. Testimony of Dr. Lowell Wood of Lawrence Livermore National Laboratory. "EMP crippling of the American military machine and of the modern American nation remain real prospects . . . EMP is a 'weapon of mass *hardware* destruction . . . even one instance can cripple the U. S. military machine and lay waste to modern American civilization." (Original emphasis)

[52] Ibid., 122.

[53] Ibid., 10. "A particular good news story is that EMP protection can be quite affordable. If EMP hardening is built in from the start, the cost of EMP hardening is a relatively small fraction of the overall system's cost, approximately 1 to 5 percent. Done after the fact, when the unprotected system has been already fielded, it can be significantly more expensive." Despite this statement, even a 5% increase in costs can make the difference between approval or rejection of weapons systems. As a result, unless hardening is specifically required by a system, it is often not pursued. See also: Ibid., 92-93. Refers to a proposed "rad-hard" strategy to " . . . focus on protection and negotiate appropriate hardness levels." See also: Makoff, 19. "The high cost of EMP hardening implies that only the most important systems will be made to withstand the pulse. A wide review of open sources indicates that the military has concerned itself nearly exclusively with protecting strategic systems to withstand EMP."

[54] Ibid., 14. "There is an insufficient commercial base to support a rad-hard industrial capability." See also: Ibid., 92. "Government and industry [rad-harding] competency has *decreased* as the industry downsizes." (Emphasis mine)

[55] Ibid., 60-66. Contains discussion of multiple means of effecting EMP hardening.

[56] Ibid., 91. "Engineers design commercial and civil satellite electronics to withstand this naturally occurring radiation. DOD satellite systems must be designed to survive much more severe radiation environments induced either by hostile actions . . . or high ambient radiation orbits . . ."

[57] Ibid., 91-92. Integrated product team results and recommendations to "generate economies of scale". See also: Ibid. 103-106, "Recommendations for Congressional Consideration".

[58] Eugene Farrell, "Electromagnetic Pulse (EMP) & High Power Microwave (HPM) Threats Packaging Requirements Information" U. S. Army ARDEC's Packaging Division. N.d. http://w3.pica.army.mil/wecac/pd/ZONE/process/emp/emp.html (28 December 1999).

[59] Makoff, 29. "Many devices exist for this purpose: transorbs, filters, fiber optic cables, careful grounding and bonding practice, etc."

[60] United States Federal Emergency Management Agency, Electromagnetic Pulse Protection Guidance, Volume I, The Theoretical Basis for EMP Protection (Washington: 1991), 4-30,d. "All three types of arresters, varistors, gas discharge tubes, and semiconductors, have advantages and limitations in areas of current-carrying capability and voltage-limiting ability and their effects on the normal operation of the circuits being protected."

[61] Ibid., 4-27,h. See also: Congress, 5. "The electric field resulting from a high-altitude nuclear detonation can be on the order of 50 kilovolts per meter with a rise time on the order of 10 nanoseconds and a decay time to half maximum of 200 nanoseconds. It is very fast."

[62] Ibid., 30. Discussion of solar radiation combining with the earth's magnetic field to cause "God's EMP", resulting in widespread power outages. "God's EMP . . . [is] . . . very small compared to a megaton burst".

[63] "Electromagnetic Pulse Testing" Public Affairs Office, White Sands Missile Range. N.d. http://www.wsmr.army.mil/PAOPAGE/PAGES/WU%2312.htm (28 December 1999).

[64] John Diamond, "Chinese See U.S. Military Weakness." The Associated Press News Service. 18 September 1997. 1. "Far from hiding these writings, Chinese authorities openly gave them to the Pentagon and promised to provide more . . . [CAPT Shen Zhongchang and co-authors from the Chinese Navy Research Institute note] . . . the U.S. Defense Department has invested $1billion in establishing a network

to safeguard its information system . . . that system remains vulnerable to jamming, attacks on command and control centers, electromagnetic pulse weapons . . . "

[65] "Chinese Theft of U.S. Nuclear Technology Reported." Facts On File News Services. 11 March 1999. http://www.2facts.com/stories/index/1999128860.asp (28 December 1999).

[66] "Energy: Plutonium-Disposal Plan Proposed; Other Developments." Facts on File News Services. 31 December 1996. http://www.2facts.com/stories/index/1996065935.asp (28 December 1999). Argued that the policy would increase the chance that individuals interested in using it in nuclear weapons could intercept the plutonium. See also: Mary Williams Walsh, "Stung by a Nuclear Sting." The Los Angeles Times, 26 January 1996, A1.

[67] Bill Gertz, "Tehran sold Scud missiles to Congolese, U.S. Spies discover systems" The Washington Times, 22 November 1999, A1.

[68] Ibid.

[69] A. K. Cebrowski, "Rebalancing the Fleet." U.S. Naval Institute Proceedings. November 1999. http://www.usni.org/Proceedings/Articles99/PROcebrowski.htm (15 December 1999).

[70] Congress, 2.

[71] Ibid., 48. "Are we confident EMP won't disable or disrupt these commercial communications systems?"

[72] Ibid., 19-20.

[73] Bruce A. Hurwitz, The Legality of Space Militarization (North Holland: Amsterdam, 1986), 108-116. The Space Treaty forbids the stationing of nuclear weapons on orbit. It does not prevent the transit of space with such weapons, for both the U.S and U.S.S.R had planned for years to do just that if, during the cold war, it became necessary to launch intercontinental ballistic missiles. Neither does international law proscribe orbital detonation. See also: Congress, 100. "Although signatories of the non-proliferation treaty are legally entitled to immunity from all nuclear attacks . . . it is widely known that we Americans contemplated, briefly and in a non-pervasive fashion, a nuclear EMP laydown on Iraq (a NPT signatory legally entitled to immunity from all nuclear attacks)." The most powerful asymmetric attack of all, the high altitude nuclear burst, is not proscribed by law.

[74] Landers, "...U.S. information warfare doctrine has to consider what could happen next in such scenarios. A hydrogen bomb exploded 200 miles over the Midwest could knock out U.S. electrical systems that make use of semi-conductors with a giant electromagnetic pulse of energy. There are some nations who might not be able to replicate our information-warfare efforts, but who might find nuclear pulse a very tempting option for evening the score."

[75] Bruce Wald, "Space Control Issues: Plausible Threats and Assurance Strategies" Unpublished annotated briefing, Center for Naval Analyses, Alexandria VA: January 1997, 40-41.

[76] Idem, "Space Control Issues in the Post-Cold-War Era" Research Memorandum, Center for Naval Analyses, Alexandria VA: January 1997, 14-31.

[77] United States Space Command, Long Range Plan (Peterson AFB, 1998), 4. "A high-altitude nuclear detonation would create electromagnetic interference against satellite communications. Only a few nations will be able to do so, but they will also rely on space-based services and products that would be vulnerable to the same effects. Nation States probably wouldn't be willing to accept fratricide of satellite systems."

[78] "Key Event: North Korea, U.S. in Nuclear Stand–Off." Facts on File News Services. August 1998. http://www.2facts.com/stories/index/v00092.htm (28 December 1999). "In August 1998 it was reported that US intelligence agencies believed that North Korea had begun constructing a large new underground nuclear plant near Yongbyon."

[79] Jane Perlez, "U.S. Asserts Pakistan Backed Hijacking of Air Indian Jetliner." The New York Times. 25 January 2000, A1.

[80] Pamela Constable, "U.N. Imposes Air, Economic Sanctions on Afghanistan Taliban Still Refuses to Hand Over Bin Laden" The Washington Post. 14 November 1999, A22.

[81] Perlez.

[82] Robert Jay Lifton, Destroying the World to Save It. Aum Shinrikyo. Apocalyptic Violence. and the New Global Terrorism (New York: Metropolitan Books, 1999), 9-10, 41, 118, 193-201.

[83] Jane Little, "Does Aum Still Pose a Threat?" British Broadcasting Corporation. 28 September 1999. http://www.rickross.com/reference/aum/aum126.html (7 January 2000).

[84] Joint pub 3-01, GL-3.
[85] Ibid., GL-6.
[86] Swicker, 22.
[87] Ibid. 23.
[88] Ibid. 25.
[89] Ibid. 24.
[90] United States Space Command, Long Range Plan (Peterson AFB, 1998), 49-71.
[91] Swicker, 26.
[92] Ibid. 20. See also: Robert Holzer, "DoD To Develop Integrated Battlefield Picture", The Worldwide Weekly Defense News, 24 January 2000, 1. "The creation of the SIAP itself will be a massive, challenging task, according to Pentagon sources and outside experts. It is intended to capture the myriad data generated by the diverse sensors, satellites and intelligence systems operated by the military services, and fuse this into a common picture that all commanders can see simultaneously. That capability will be fundamental to integrating the various missile defense platforms now under development . . . " See also: Idem, "U.S. Army, Air Force To Use Navy Sensor Net", The Worldwide Weekly Defense News, 24 January 2000, 4. "In fact, CEC is considered a leading candidate to serve as the nucleus of the Pentagon's embryonic effort to build a military-wide system for battlefield awareness of the threat from enemy missiles."
[93] Congress, 8, 9.
[94] "The Almanac of Seapower 1999", Navy League of the United States, January 1999, 106-108, 110-112, 146-150. Article discusses current and projected inventory of all Aegis capable cruisers and destroyers. The last planned Aegis capable ship will begin construction in 2003. When all Aegis ships are available, a total of 84, 27 CG's and 57 DDG's will be available to conduct TMD launches.
[95] Swicker, 22-23.
[96] Donald R. Morris, The Washing Of The Spears (New York: Simon & Schuster, 1965), 297-298. "An excellent single-shot breech-loading rifle. . . . The action was simple and sturdy, and in trained hands the rifle was accurate to a thousand yards and more . . . even an average marksman could score hits at 300 or 400 yards."
[97] Ibid., 297. "Very few battles called for the expenditure of seventy, or even fifty rounds." See also: Ibid., 371. See also: Ian Knight, The Anatomy Of The Zulu Army, from Shaka to Cetshwayo 1818-1879 (London: Greenhill Books, 1995), 19-20. See also: Ian Castle and Ian Knight, Fearful Hard Times The Siege and Relief of Eshowe, 1879 (London: Greenhill Books, 1994), 11.
[98] David S Alberts, Network Centric Warfare 2nd ed. (Washington:: C4ISR Cooperative Research Program, 1999), 173.
[99] Congress, 30-31. "The integrated circuit density that we see at the present time is nearly a factor of 10,000 greater than it was just a quarter century ago, and that basically says that the vulnerability of the individual devices have increased correspondingly. There is reason to believe that the semiconductor-based portions of our communication system, which is to say essentially all of it, would be extremely EMP vulnerable. Measurements done on individual systems certainly support that projection."
[100] Morris, 372-377. "The regimental reserve for each battalion was packed in heavy wooden ammunition boxes, and the lid of each crate was held down by two copper bands, each fastened with nine large screws. . . .They undoubtedly started to loosen the screws on at least one of the crates early in the fight, . . . the screws were rusted into the wood and hard to start. Neither man [supply officer] would have been likely to open more than one box at a time . . . for each and every one [cartridge] would have to be accounted for . . . after the fight." During the heat of battle, when one officer from a different battalion took cartridges from his wagon, a supply officer reportedly said "For heaven's sake don't take that, man for it belongs to our battalion."
[101] "Proliferation Detection Systems." Nonproliferation, Arms Control, and International Security. N.d. http://vvc.llnl.gov/vvc/room/exhibits/intlsec/nai/DOCS/4/prolif.html (13 January 2000).
[102] "Detection of Smuggled Nuclear Materials." Nonproliferation, Arms Control, and International Security. N.d. http://vvc.llnl.gov/vvc/room/exhibits/intlsec/nai/DOCS/2/techfiss2.html (13 January 2000). See also: "WATS." Nonproliferation, Arms Control, and International Security. N.d. http://vvc.llnl.gov/vvc/room/exhibits/intlsec/nai/DOCS/1/technet2.html (13 January 2000). See also: "HRIS" Nonproliferation, Arms Control, and International Security. N.d. http://vvc.llnl.gov/vvc/room/exhibits/intlsec/nai/DOCS/2/techrem2.html (13 January 2000).

[103] "Remote Sensing." Nonproliferation, Arms Control, and International Security. N.d. http://vvc.llnl.gov/vvc/room/exhibits/intlsec/nai/DOCS/2/techrem.html (13 January 2000).

[104] "Remote sensing system for nonproliferation tested over Livermore." NEWStand. 1 May 1998. http://vvc.llnl.gov/vvc/room/exhibits/intlsec/nai/DOCS/2/5-1-98airport.html (13 January 2000).

[105] "Networked Detectors." Nonproliferation, Arms Control, and International Security. N.d. http://vvc.llnl.gov/vvc/room/exhibits/intlsec/nai/DOCS/1/technet.html (13 January 2000).

[106] Cebrowski.

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