REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
06-04-2015	Future Wars	AY 14 - 15

4. TITLE AND SUBTITLE

Dynamic Deterrence: The Modernization of Nuclear Deterrence to Meet Dynamic Future Threats

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

MICHAEL D. MAGINNESS, Maj, USAF

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

USMC SCHOOL OF ADVANCED WARFIGHTING
3070 Moreell Avenue, Quantico, VA, 22134

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

USMC SCHOOL OF ADVANCED WARFIGHTING
3070 Moreell Avenue, Quantico, VA, 22134

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

13. SUPPLEMENTARY NOTES

14. ABSTRACT

Nuclear deterrence embodied the ultimate expression of United States national security for much of the 20th Century. Unfortunately, future adversaries invalidate present deterrence assumptions while the means and modes of United States deterrence remain static. The seriousness of future nuclear threats—including a potential war of national survival—has not been backed by action. Regional states confront us as peer adversaries, replete with highly capable nuclear weapons and delivery systems, while simultaneously harboring terrorist factions. To maintain a national strategic asymmetric advantage, planners must understanding the future operating environment, devise new strategies, and wield the correct weapons to deter future potential adversaries. United States nuclear deterrence, equipped to deter in all domains and flexible to meet emerging threats, ensures superiority along the full spectrum of warfare while providing a strategic asymmetry supporting national policy.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			MICHAEL D MAGINNESS, Maj, USAF
UNCLASS	UNCLASS	UNCLASS	UNL	33	19b. TELEPHONE NUMBER *(Include area code)* 713-922-5633

United States Marine Corps
School of Advanced Warfighting
Marine Corps University
3070 Moreell Avenue
Marine Corps Combat Development Command
Quantico VA 22134

FUTURE WAR PAPER

DYNAMIC DETERRENCE: The Modernization of Nuclear Deterrence to Meet Dynamic Future Threats

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

MICHAEL D. MAGINNESS, Maj, USAF

AY 2014-15

Mentor: Wray R. Johnson, PhD

Approved: _____

Date: 09 Jan 2015

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Introduction

Nuclear deterrence embodied the ultimate expression of United States national security for much of the 20th Century. Unfortunately, future adversaries invalidate present deterrence assumptions while the means and modes of United States deterrence remain static. The seriousness of future nuclear threats—including a potential war of national survival—has not been backed by action. Regional states confront us as peer adversaries, replete with highly capable nuclear weapons and delivery systems, while simultaneously harboring terrorist factions. To maintain a national strategic asymmetric advantage, planners must understanding the future operating environment, devise new strategies, and wield the correct weapons to deter future potential adversaries. United States nuclear deterrence, equipped to deter in all domains and flexible to meet emerging threats, ensures superiority along the full spectrum of warfare while providing a strategic asymmetry supporting national policy.

Background

Nuclear nonproliferation is a lofty goal for any nation. However, current reductions in nuclear weapons may encourage nuclear proliferation—the exact opposite effect of our intent. Destabilizing effects from reduced United States strategic capabilities likely will encourage nations, both friendly and adversarial, to "nuclearize".

Nuclear force reductions arise from two main sources. First, diplomatic engagements, codified under the Strategic Arms Reduction Treaty (START), are often responsible for a reduction in nuclear forces.[1] In-kind reductions of both allied and adversary stockpile increase nuclear surety while preserving force parity and deterrence.[2] The second, but arguably more dangerous, source of force reduction stems from public opinion and political agenda. Notable former public officials and highly respected politicians, such as George Schultz, William Perry,

Henry Kissinger, and Sam Nunn posit a vision highlighting the "importance of...a world free of nuclear weapons as a guide to our thinking about nuclear policies."[3]

Whether guided by treaty adherence or altruistic motives, the bottom line is that United States nuclear forces are getting smaller but other nations are not following our lead. As of 2012, Russia, China, Pakistan, India, and North Korea had, within the last five years, or will, by 2017, field a major new nuclear weapons system (reference Appendix A, Figure 1).[4] Conspicuously absent from this modernization trend is the United States and the United Kingdom.

Post-Cold War reductions in U.S. nuclear weapon stockpiles, combined with increased worldwide proliferation and modernization, degrade the military and political asymmetric advantage that the United States has relied upon since the end of World War II. But, in a multi-polar world, the threat of nuclear attack and blackmail remain as prevalent as ever. Herman Kahn's statement, "a moment of anger, a surge of emotion, a seemingly innocuous miscalculation or accident...can have catastrophic consequences," is as true today as during the Cold War.[5] But, unlike the Cold War, planners must look beyond quantity to achieve such an asymmetry. Purpose-designed weapons systems operating in conjunction with conventional means of deterrence provide a better future strategic asymmetry to the United States and her allies.

The Mixed Actor Regional State and Deterrence

Current adversaries fall into one of three main categories: peer competitor, regional power, and non-state actor. Since the end of the Cold War, war planners generally classify an adversary before selecting the appropriate response. The conventional, force-on-force approach of Operation DESERT STORM contrasts dramatically with ongoing counterinsurgency

operations in Afghanistan. Responses are chosen based on the adversary's perceived mode of operation. In many ways, this approach makes perfect sense—peer competitors warrant a different response than non-state actors. In that regard, nuclear deterrence is an option generally reserved for nations in the peer-competitor category.

Future Deterrence of Peer Adversaries

A strong nuclear arsenal, appropriately funded and manned, continues to deter peer adversaries--primarily Russia and China for the foreseeable future. Current trends among these nations suggest increased prominence of traditional modes of deterrence in response to future United States strategic policy. According to former Secretary of Defense Robert Gates, "Russia has embarked on an ambitious path to design and field new [presumably nuclear] weapons." He added, "Russia today...has neither the money nor the population to sustain its Cold War conventional force levels. Instead, we have seen an increased reliance on its nuclear force with new ICBM and sea-based missiles."[6] While some investment is required to recapitalize an aging American nuclear infrastructure, paradigmatic shifts in weapons or strategy are unnecessary in countering this threat.

Effective deterrence of peer-competitors requires evolutionary improvements in United States nuclear deterrence. Future peer-competitor deterrence falls in line with recommendations from the New Deterrent Working Group, including infrastructure modernization, Triad maintenance, and strengthening of the nuclear weapons laboratories under the United States Department of Energy.[7] Unfortunately, these evolutionary improvements do not fully address future scenarios involving mixed-actor regional states. (Appendix A, Figure 2 highlights world nuclear stockpiles)

The Demise of Rational Deterrence Theory

Adversary classification loses its utility when considered against regional-state or non-state actors. Nations possessing both nuclear weapons and sponsoring terrorist groups further distort the lines of distinction. Advancements in the range and capability of nuclear delivery systems enable adversary action akin to a peer adversary or a regional power (reference Appendix A, Figure 3).

Historically, deterrence is tailored to an adversary's classification. For example, adversarial superpowers warrant strategies such as massive retaliation or MAD. In contrast, regarding regional powers, economic sanctions, inspections, and control measures are thought to be more effective. Future adversaries exhibiting characteristics of all three present challenges that current United States strategy is ill equipped to handle. This inadequacy provides an adversary with an asymmetric advantage—they control the tempo and escalation of a conflict. Thus, such adversaries invalidate core principles of rational deterrence theory.

Three postulates govern rational deterrence theory. The first two are common to rational choice models and the third is specific to deterrence theory.

1. *Rational actor assumption.* According to this postulate, actors have exogenously driven preferences and choice options and they seek to optimize their preferences in light of other actions, preferences, and options.
2. *Principal explanatory assumption.* Here the variation in outcomes is explained by differences in opportunities.
3. *Principal substantive assumption.* Conceptually, the state acts as if it were a unitary rational actor.[8]

In addition to the postulates above, a core assumption of classical deterrence theory classifies conflict as the worst possible outcome and assumes both players are instrumentally rational.[9] Current modes of nuclear deterrence rest firmly upon these assumptions and postulates—it is a system well designed to deter a unitary, rational actor, grounded in the belief that war is the worst possible outcome.

Current nuclear deterrence is well suited for success in a bipolar world, similar to the Cold War, or against peer adversaries in which the state behaves as a unitary rational actor. According to international relations theorist John J. Mearsheimer, "Deterrence is most likely to hold when the costs and risks of going to war are obviously great. The more horrible the prospect of war, the less likely it is to occur."[10] The key to his statement is the concept of rational actor—it must be in an adversary's best interest not to go to war.[11]

Actors simultaneously fulfilling the role of peer adversary, regional power, and non-state actor invalidate the above. Instead, a mixed actor system emerges. According to Oran Young:

> The mixed actor view envisions a situation in which several qualitatively different types of actor interact in the absence of any settled pattern of dominance-submission (or hierarchical) relationships. In such a system, questions concerning political stature, competencies, rights, obligations, and so forth cannot be dealt with in terms of a simple rule indicating supremacy of one type of actor and, therefore, they must be worked out on an *ad hoc* basis with different results for different types of relationships.[12]

The ad hoc nature of the problem greatly intensifies complexity. Future regional powers may possess nuclear weapons and have a developed intercontinental delivery capability. These states may also sponsor or harbor non-state terrorist groups. Simultaneous actions undertaken within

each category complicate matters—deterrence must compete among different actor types (peer adversary, regional power, non-state actor).

Iran has demonstrated characteristics indicative of a regional power trending along this dangerous path. For example, Iran continues to seek a nuclear capability all the while modernizing its ballistic missile delivery system (reference Appendix A, Figure 5). James Clapper, the director of national intelligence, remarked to the Senate Select Committee in March 2013 that:

> Iran has demonstrated an ability to launch small satellites, and we grow increasingly concerned that these technical steps—along with a regime hostile toward the United States and our allies—provide Tehran with the means and motivation to develop larger space-launch vehicles and longer-range missiles, including an intercontinental ballistic missile.[13]

Deterring Iran may be accomplished in much the same manner as deterring the former Soviet Union. Iran, fits well within the paradigm of classical deterrence theory. Unfortunately, Iran exhibits characteristics of a mixed actor and deterrence designed for peer adversaries may prove ineffective. For example, Iran's current relationship with Hizballah consists of support in excess of $100M per year and includes weapons systems such as anti-tank guided missiles, anti-ship missiles, and thousands of rocket and artillery systems.[14] Additionally, Iran maintains ties with organizations such as the Palestinian Islamic Jihad, Hamas, and on occasion worked with al-Qa-ida and the Taliban.[15] Thus, Iran is a mixed actor.

Terror sponsoring or supporting regional powers with access to nuclear weapons require an appropriate deterrent. For one thing, they may view war as an acceptable outcome. For them, conflict may be an acceptable, even preferable, means to an end. Nuclear deterrence planned solely as a high-end retaliatory measure is unsuited to deter such a mixed actor regional state.

Deterrence Calculations

Future adversaries view nuclear weapons as weapons of war, rather than weapons of policy. According to the RAND Corporation, "Defense planners in the United States and elsewhere must begin now to confront the possibility that, in the face of superior U.S. conventional forces, adversaries of this class [regional powers] could consider the use of nuclear weapons as an attractive option."[16]

Current planning considerations place nuclear weapon release above the *Bizarre Crises* escalation criteria on Hermann Kahn's Nuclear Escalation Ladder (figure 6). Regional conflict and limited U.S. response assumes nuclear restraint. Belief in sequential and orderly conflict escalation encourages planners to separate nuclear and conventional action, according to this line of thought. Conflicts remain conventional until the crossing of well-defined thresholds. Conventional powers such as the United States control conflict intensity and tempo within this framework.

Mixed actors are unlikely to view war as a sequential progression of intensity. RAND identifies three behaviors that may characterize the regional power, mixed actor adversary:

1. Leaders may believe that their lives and regimes are at risk from the outset of conflict in that U.S. modes of war have demonstrated a desire to disable enemy leadership from the outset.
2. Adversary leadership may be forced into a use-or-lose dilemma: U.S. conventional forces may destroy a small nuclear arsenal before it can be used.
3. Operational considerations dictate that United States forces are weakest in the deployment phase of a conflict and most vulnerable to nuclear weapons use.[17]

Regional powers are unlikely to invest in multiple command and control systems and tasking of integrated defense nodes with both nuclear and conventional command and control increase the likelihood of nuclear release. In such a case, attacks on enemy command and control systems encourage the first use of nuclear weapons. In short, adversary leadership must command nuclear release while they still have the ability. Adversary nuclear use in future mixed actor regional state scenarios may occur as early as *subcrisis maneuvering* (figure 6).

Resolution of this challenge centers on two concepts: American nuclear capability and credibility. Future planners should become as familiar with these concepts as Cold War planners were with MAD.

Adapting Deterrence for Dynamic Threats

Capability and credibility provide for a strategic advantage in regional and limited conflicts. Nations that can "de-nuclearize" an adversary at will control conflict intensity and tempo. National will, strategic planning, and weapon type determine credibility. Weapon design and operational factors determine capability.

Acquisition of a low-observable weapon and a long-range, survivable delivery platform provide planners with capability. Sub-kiloton yield warheads and integrated operational planning provide credibility. These concepts, properly appreciated, enable a dynamic deterrence option that is effective against the depth and breadth of mixed actor regional state actions.

The 2010 Nuclear Posture Review (NPR) drives current operational planning. Concluding that the sole purpose of nuclear weapons is deterrence of nuclear attacks on the U.S., it posits that the U.S. would only "consider the use of nuclear weapons in extreme circumstances to defend the vital interests of the United States."[18]

Mixed actor regional state frameworks combined with NPR guidance reduce the credibility and deterrent value of existing nuclear forces. Current weapon systems limitations prevent successful integration: current guidance definitively separates nuclear and conventional action. Nuclear action, according to the NPR, is unique and only *in extremis*.

Even under alternate guidance, current nuclear capabilities drive operational planning—that is, nuclear stockpiles determine employment options. This phenomenon is an inversion of previous planning and weapons development relationships. Current U.S. nuclear weapons trace their design to Cold War operational planning—Cold War thinking has produced an "all or none" outlook.

However, future adversaries may employ nuclear materials in a manner that to a point a U.S. nuclear response is unrealistic. Regaining control of conflict tempo and intensity requires weapons commensurate with the strategy.

Nuclear Weapons Systems

Three characteristics decrease current nuclear weapons effectiveness in future, regional state conflicts. First, current weapons are too destructive for credible deterrence short of massive retaliation.[19] Second, limited visibility of current weapons reduces their deterrence value. Signaling escalation is difficult from a submarine or an ICBM silo. Finally, weapon systems such as Air Launched Cruise Missiles (ALCM) and other current delivery platforms lack the necessary survivability to guarantee effects.

Projecting deterrence in the future requires a survivable sub-kiloton yield weapon. Smaller yields serve to convince adversaries of American willingness to use the weapon while increased survivability convinces them of the weapon's ability to achieve desired effects.

Combined, these attributes substantially lower the value and utility of an adversary's nuclear capability.

Deterring future regional-state, mixed actors requires flexibility. Future weapon systems therefore require the range and speed to enabling first-strike capability and the survivability to penetrate advanced air defense systems. These attributes enable deterrence on multiple levels and provide maximum freedom of action for planners.

Adversaries aware of their own stockpile vulnerability are unlikely to escalate conflicts. But, convincing an adversary to act according to this awareness requires two things. First, the weapon system effect must be proportional, enough to make its use plausible. Second, the weapon must be survivable, enough to reach desired targets and function as designed. Most importantly, adversaries must believe that the United States will use these weapons. They must also believe that weapons will work. Therefore, the best weapon system is small-yield, high speed, highly accurate, and low-observable cruise missiles launched from standoff distances by long-range, low-observable delivery platforms.

Next Generation Cruise Missile and Warhead

ICBM and SLBMs continue to provide deterrence to U.S. peer-adversaries. Unfortunately, highly destructive weapons are not credible to mixed-actor regional states. For example, any attempt to attack North Korean nuclear capability with current ICBM technology would yield unacceptable collateral damage (Appendix A, Figure 7). A single Minuteman III type warhead, set for a surface detonation, yields an initial dangerous fallout contour of 11,320 KM^2. In this scenario, initial radiation plumes would affect Seoul and key western ports in South Korea before slowly drifting towards Japan. By comparison, the same target set, serviced with a sub-kiloton yield weapon, would produce initial radiation plumes within $2KM^2$. Figure 8,

Appendix A demonstrates the relatively localized impact of a sub-kiloton yield weapon. Thus, primary and secondary effects are controllable and acceptable.

Weapon accuracy must increase as destructive power decreases. GPS-aided navigation is a solution in permissive environments. Proliferation of GPS denial technology suggests future conflicts will occur in contested and degraded environments. According to the GPS Test Center of Expertise, "over-reliance on GPS for critical applications could leave us vulnerable to future asymmetric threats. To function properly, GPS receivers must track low-power satellite signals which are very susceptible to jamming or other interference."[20] Therefore, a small-yield cruise missile variant obtains superior accuracy through means other than GPS.

Mature technology provides potential solutions to degraded operations. A version of Terrain-Aided Navigation (TAN) or Terrain Contour Matching (TERCOM) passing data to an Inertial Navigation System (INS) delivers acceptable midcourse accuracy with no reliance on GPS (Appendix A, Figure 9). TAN provides navigation by determining vehicle location relative to local terrain whereas TERCOM operates on the premise that certain local geographic locations are uniquely defined.[21] Advances in computing and sensor technology further refine the accuracy of TERCOM with the addition of 3-D terrain reconstruction.[22]

Accuracy during the terminal approach phase ultimately determines weapons effectiveness—midcourse navigation need only be accurate enough to deliver the weapon to the terminal area within parameters for final corrections. Edge-matching technology or Automatic Target Correlation (ATC) is another potential solution for high accuracy in contested and denied environments. ATC is a method of, "determining [the] location of a target image within a two dimensional input image by employing a three-dimensional reference image."[23] Simply put, ATC is the use of organic weapon sensors to match a preprogramed target image with real-world

sensor data (Appendix A, Figure 10). Final course corrections rectify the difference between the preprogramed image and current sensor data.

Survivability is the final characteristic necessary in credible deterrent weapons. Future survivability hinges on the weapon's radar signature and speed. Russia's recent sale of the S-300PMU2 air defense system to Syria and Iran demonstrate the necessity for a stealthy cruise missile.[24] The S-300PMU2 has a limited anti-ballistic capability and can engage aircraft and cruise missile targets flying from 10M to 27KM in altitude and at speeds up to 10,000KM per hour.[25] Systems similar to the S-300PMU2 decrease the survivability of a non low-observable weapon to a point where its credibility is doubtful. Current U.S. ALCM variants have open source X-band detection ranges of between 25-125NM (Appendix A, Figure 11). Air defense capabilities will keep pace with low-observable technology and multiple methods of survivability are necessary in weapons design.

Low observable weapon design coupled with signature-management planning methods decrease adversary detection ranges—even if detected, its engagement and destruction are difficult. Shaping and the use of radar absorbing materials are the two most effective physical signature reduction methods.[26] The aim of shaping is to reflect radar energy to certain, irrelevant directions, thus keeping the radar cross-section (RCS) low. Radar absorbing materials (RAM) act to absorb received radar energy and convert it to heat. RAM is typically employed in areas where shaping is impractical.

Stealthy cruise missiles are detectable and require optimum route planning. For example, missiles may employ a version of common low-observable auto-routing (CLOAR). CLOAR mission planners calculate the lowest cost route enabling the best cross-section of survivability and mission success (Appendix A, Figure 12). CLOAR provides deconfliction within the model;

however, other airborne assets may be in conflict with weapons effects and missile routes. Codified procedures for asset deconfliction between nuclear and conventional planners are necessary. Ideally, weapon payload is irrelevant to cruise missile route planning. Single source route planning enables asset deconfliction while weaponeering and targets effects remain segregated as applicable.

Finally, a next generation cruise missile must be fast. Proliferation of advanced air defense systems, such as the S-300PMU2, dictate that neither stealth nor speed guarantee survivability—a balance of the two must be relied upon. Vehicles with hypersonic speed survive by decreasing an adversary's engagement time.[27] Ongoing research, by the Committee on Future Needs for Survivability, suggests survivable weapons combine high-speed penetration capabilities and exhibit contemporary or better stealthy signature levels.[28]

Figure 13 in Appendix A demonstrates the effect of speed and stealth versus a generic surface-to-air system. Above $0.1M^2$ RCS, speed simply decreases time spent in engagement zones. However, below $0.1M^2$, RCS speed exponentially decreases an air defense system's lethality. Next generation cruise missile design accounts for the correct combination of speed and stealth promoting survivability and capability.

The next generation cruise missile must be credible in its capability to complete the kill chain.[29] Its employment in a nuclear role, however, indicates a failure of design—the great paradox of nuclear weapons is that they are truly effective when not used. The weapon's main deterrent value is in its perceived capability. Adversaries must believe that, if employed, the weapon will destroy intended targets with a high degree of certainty.

Demonstrations of escalation, de-escalation or national resolve are beyond the capabilities of the next generation cruise missile. The appropriate delivery platform best accomplishes the early stages of deterrence.

Next Generation Delivery Platform

Delivery platforms must be long-range capable and low observable. Much of the deterrent value of an air-breathing asset with cruise missile is due to selective visibility.[30] ICBMs and SLBMs lack the ability to demonstrate national resolve as the situation dictates—only the visible generation, deployment, and launching of long-range deliver platforms can leverage the benefits of strategic messaging. According to former USAF Vice Chief of Staff, General John Loh:

> The long-range, penetrating nuclear bomber has characteristics that ballistic missiles do not have. Bombers give our president more options than ballistic missiles. He can launch them immediately when crises arise in hot spots around the world to reassure ourselves and our allies, and then recall them after their deterrent role has worked. [31]

Future adversaries are undeterred by visibility lacking in capability. Next generation delivery platforms require the means to penetrate active enemy air defenses. But, as previously noted, destruction of an adversary's air defense system may trigger the early release of nuclear weapons. The ability to de-nuclearize an adversary before creating a permissive environment greatly bolsters deterrence.

Next generation delivery platforms require a long-range capability. They must respond to situations prior to normal deployment schedules. Long-range delivery platforms hold adversary targets at risk from the start of hostilities (Appendix A, Figure 14). Nations assuming the loss of nuclear capabilities at the start of hostilities are less likely to select this option.

Finally, in the case of mixed actor regional states, nuclear control may slip to non-state or terrorist factions within the government, requiring a quick response. In this case, a first strike against an adversary's nuclear capability may be in the best interest of the U.S. Even if not selected, the presence of a first-strike option allows planners a range of flexibility they currently lack. Similar to the "hair trigger" response of the Cold War, future operations include rapidly executable nuclear options.

Acquisitions personnel view a next generation delivery platform as utilitarian, rather than a "silver-bullet" solution--fleet size and mission capable rates are important. Of the pair, next-generation cruise missiles are the more capable partner. Next generation delivery platforms, aside from the aforementioned characteristics, require procurement in numbers large enough to support multiple contingencies while still fulfilling traditional nuclear deterrence missions.

Pairing the correct delivery platform with a capable cruise missile provides latitude for future planners. To an adversary, small yields make weapon use plausible. Furthermore, a fast and stealthy cruise missile makes its use credible. Finally, the capabilities of a next generation delivery platform make deterrence timely and visible. Combined, these characteristics allow deter mixed actor regional states and preserve conventional freedom of movement.

Conclusion

For a brief period in the 1990s the United States stood atop a unipolar world. The U.S. was without peer as the undisputed world leader in diplomacy, information, economics, and military strength. The value of nuclear weapons in such a world was dubious—planners had other, more politically acceptable means to deter potential adversaries.

Current trends suggest, however, that the unipolar world is only short term. Therefore, future planners face the inherent complex of a multi-polar world, one exasperated by the

emergence of mixed actor regional states. Military operations may occur in environments lacking the predictability of rational actors. The resultant uncertainty and unpredictability limits freedom of action.

Dynamic deterrence preserves freedom of action. Planners cannot rely on rationality to control escalation—Kahn's Ladder of Nuclear Escalation is inapplicable. Current means of deterrence, well suited for the former bipolar world, are unsuited for future challenges. Means and modes of bipolar deterrence lack credibility with mixed actor regional states.

Appropriate weapon systems and planning considerations commensurate with operating environments will secure deterrence credibility. Adversaries must believe that the United States will employ these new weapons if necessary. Once employed, weapons must achieve desired effects with high-degrees of probability.

A highly capable cruise missile paired with a next-generation delivery platform project this credibility. Low-yield warheads, fast and stealthy cruise missiles, and the ability to function in contested and degraded environments are means commensurate with the mission. Next generation delivery platforms combine range to meet global threats, numerical availability to support multiple contingencies and survivability in high-threat environments.

Nuclear weapons, properly configured and employed, provide critical deterrence to future adversaries. Capable weapons and integrated planning enable freedom of action and assuage fears of adversary employment of nuclear weapons. Properly integrated and equipped, dynamic deterrence retains an advantage along the full spectrum of warfare while preserving a national-level strategic asymmetry.

Endnotes

[1] The New START sets aggregate limits of 1,550 nuclear warheads on deployed ICBMs, deployed SLBMs and deployed heavy bombers equipped for nuclear armament. New START entered into force on February 5, 2011 with a requirement for meeting the central limits on arms by February 5, 2018. "New START," U.S. Department of State, October 16, 2014, accessed October 19, 2014, http://www.state.gov/t/avc/newstart/index.htm.

[2] Nuclear Weapons Surety is defined as: Material, personnel, and procedures which contribute to the security, safety and reliability of nuclear weapons and the assurance that there will be no nuclear weapons accidents, incidents, unauthorized weapon detonations, or degradation in performance at the target. United States, United States Air Force, Secretary of the Air Force, *Air Force Nuclear Weapons Surety Program*, 91-101 ed, AFI (Washington D.C.: HQ USAF/SE, 1997), 18.

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[10] John J. Mearsheimer, "Back to the Future: Instability in Europe After the Cold War," *International Security* 15, no. 1 (Summer 1990): 17, http://mearsheimer.uchicago.edu/pdfs/A0017.pdf.

[11] In the rational choice model, an actor prioritizes national goals, identifies the various options available and derives the likely consequences of making a particular choice. Consequences are calculated primarily through the variables of gain vs. loss and likelihood of various outcomes. The option ranked highest—optimal choice—provides the actor with maximum payoff. From: Branislav L. Slantchev, "Introduction to International Relations Lecture 3: The Rational Actor Model"" (lecture, Department of Political Science, University of California, San Diego, December 2, 2014).

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[13] "Pentagon Report: Iran Could Test an Intercontinental Ballistic Missile by 2015," Missile Threat, April 25, 2013, accessed December 5, 2014, http://missilethreat.com/pentagon-report-iran-could-test-an-intercontinental-ballistic-missile-by-2015/.

[14] *Iran's Support for Terrorism in the Middle East,* Senate Committee on Foreign Relations. (July 25, 2012) (testimony of Daniel Byman).

[15] *Ibid.*

[16] David Ochmanek and Lowell H. Schwartz, *Nuclear-Armed Regional Adversaries: How Deterrable Are They Likely to Be?,* report, 2008, xi, http://www.rand.org/content/dam/rand/pubs/monographs/2008/RAND_MG671.pdf.

[17] Ibid, 39.

[18] *Nuclear Posture Review Report* (Washington, DC: U.S. Dept. of Defense, 2010), viii, accessed September 5, 2014, http://www.defense.gov/npr/docs/2010%20Nuclear%20Posture%20Review%20Report.pdf5.

[19] Massive retaliation likely found its beginnings in the Truman administration when the American stockpile of nuclear weapons greatly exceeded Soviet stores. The strategy's primary purpose was to oppose the size of the Soviet Union's conventional army with a force that was smaller, more mobile, and superior in strength due to the threat of massive force behind it. From: Samuel J. Kessler, "From 'Massive Retaliation' to 'Flexible Response':

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[20] Maj David Hoey and Paul Benshoof, *Civil GPS Systems and Potential Vulnerabilities*, technical paper no. OMB 0704-0188 (Eglin AFB: 46th Test Wing, 2005).

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[22] For further reading on potential advances to TERCOM navigation, reference LI LiChun et al., "A New Navigation Approach of Terrain Contour Matching Based on 3-D Terrain Reconstruction from Onboard Image Sequence," *Science China* 53, no. 5 (May 2010), accessed November 2014, doi:10.1007/s11431-010-0170-9.

[23] Ruey-Yuan Han, et al.. "United States Patent: 7,397,970B2: Automatic Scene Correlation and Identification," July 8, 2008.

[24] As of August 2014, the status of the Syrian S-300 air defense order was cancelled under the relevant UN Security Council Resolution 1929. Iran still considers this deal as active. Regardless, the orders demonstrate the willingness of Russia to sell front-line air defense systems to regional-states who possess a nuclear capability and are state sponsors of terrorism. S-300PMU2 acquisition data from: Jeremy Binnie, "Russia Cancels Syrian S-300 Deal," IHS Jane's 360, August 13, 2014, accessed December 19, 2014, http://www.janes.com/article/41819/russia-cancels-syrian-s-300-deal.

[25] Anthony H. Cordesman, Aram Nerguizian, and Ionut C. Popescu, *Israel and Syria: The Military Balance and Prospects of War* (Westport, CT: Praeger Security International, 2008), 187.

[26] Konstantinos Zikidis, Alexios Skondras, and Charisios Tokas, "Low Observable Principles, Stealth Aircraft and Anti-Stealth Technologies," *Journal of Computations & Modeling* 4, no. 1 (2014): 140-150, accessed December 2014, http://www.scienpress.com/Upload/JCM/Vol%204_1_9.pdf.

[27] *Future Air Force Needs for Survivability* (Washington, D.C.: National Academies Press, 2006), 61.

[28] *Ibid*, 69.

[29] The kill chain is often referred to as F2T2EA, or Find, Fix, Track, Target, Engage and Assess—next generation cruise missiles will be called upon to engage.

[30] Selective visibility refers to the ability to stage an asset as needed in order to fulfill a deterrence tasking while preserving the ability to stealthily penetrate an adversary's air defense system when needed.

[31] Gen. John M. Loh, "Extended Deterrence," *Defense News*, January 14, 2013, accessed December 19, 2014, http://www.defensenews.com/article/20130114/DEFFEAT05/301140025/Extended-Deterrence.

Glossary

ALCM	Air Launched Cruise Missile
ATC	Automatic Target Correlation
CLOAR	Common Low-Observable Auto Router
ICBM	Intercontinental Ballistic Missile
INS	Inertial Navigation System
MAD	Mutually Assured Destruction
NPR	Nuclear Posture Review
RAM	Radar Absorbing Material
RCS	Radar Cross Section
SLBM	Sea Launched Ballistic Missile
START	Strategic Arms Reduction Treaty
TAN	Terrain Aided Navigation
TERCOM	Terrain Contour Mapping
WMD	Weapons of Mass Destruction

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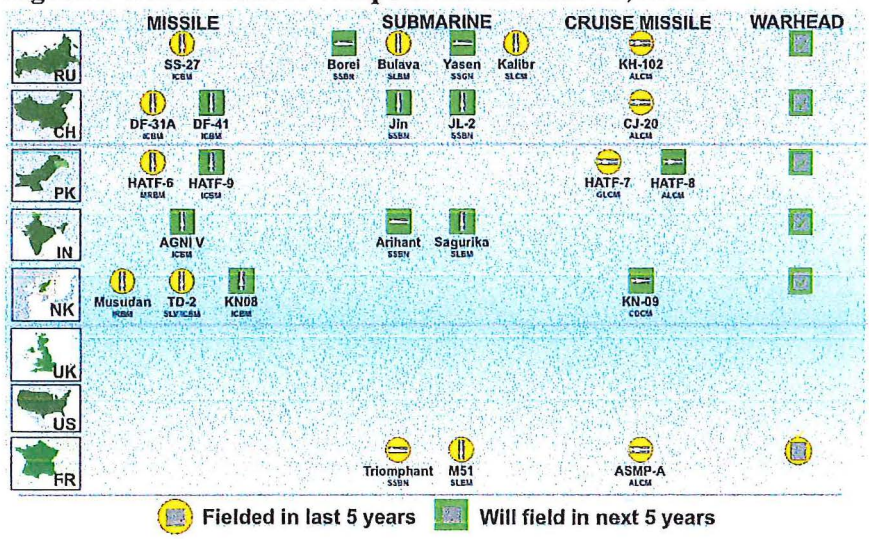
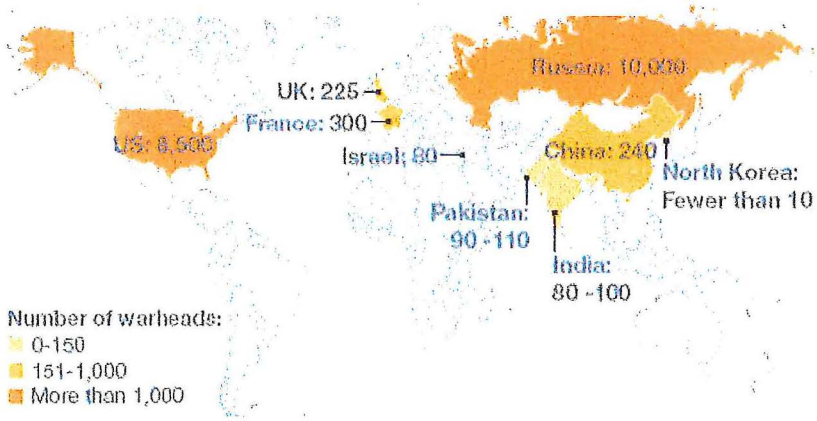
Appendix A: Supporting Figures

Figure 1 World Nuclear Weapons Modernization, 2013.



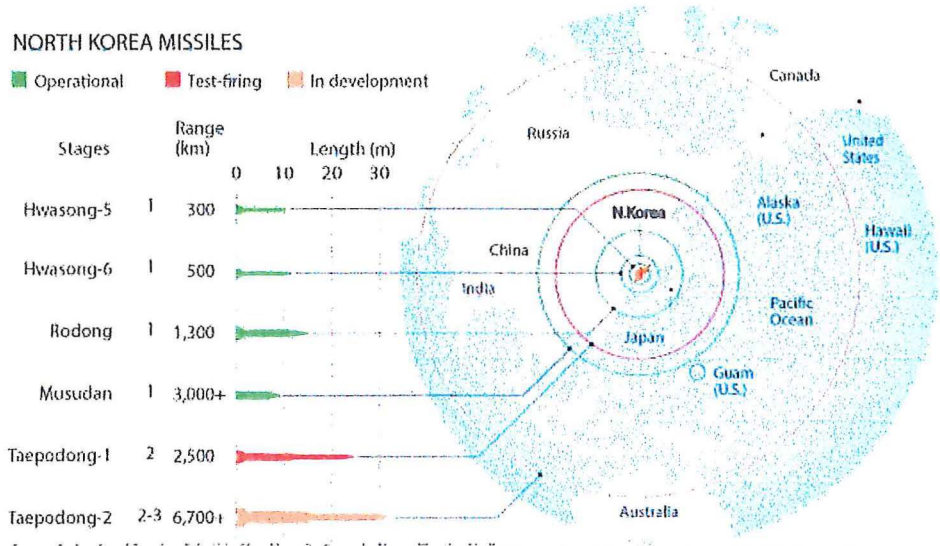
Source: James M. Kowalski, Lt Gen, "Air Force Global Strike Command" (speech, Daedalians Meeting, Columbus Air Force Base, April 2013).

Figure 2 World Nuclear Weapons Stockpiles, 2012



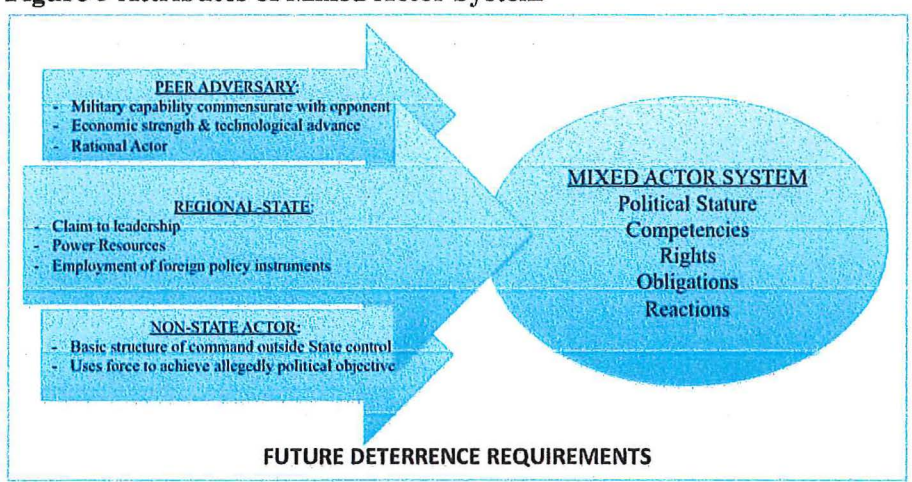
Data From: "Status of World Nuclear Forces - Federation Of American Scientists," Federation Of American Scientists, accessed December 20, 2014, http://fas.org/issues/nuclear-weapons/status-world-nuclear-forces/

Figure 4 North Korean Strategic Capabilities, 2013



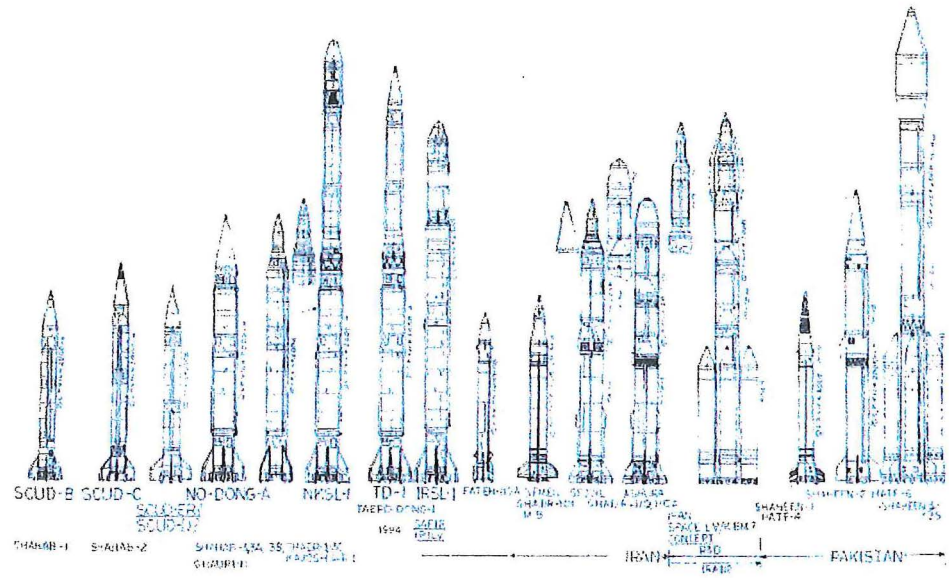
Source: Herman, Steve. "N. Korea Threatens 'Pre-Emptive Nuclear Attack'" Voice of America. March 7, 2013. http://www.voanews.com/content/north-korea-threatens-preemptive-nuclear-attack-on-us/1616792.html.

Figure 3 Attributes of Mixed Actor System



Source: Mixed Actor: Oran Young, "The Actors in World Politics," ed. J. Rosenau, V. Davis, and M. East, in *The Analysis of International Politics* (New York: Free Pr., 1972).; Non State Actor: *Armed Non-State Actors: Current Trends & Future Challenges*. Working paper no. 5. Geneva: Democratic Control of Armed Forces, 2015.

Figure 5 Iranian Solid Motor Launch Vehicle Program, 2010



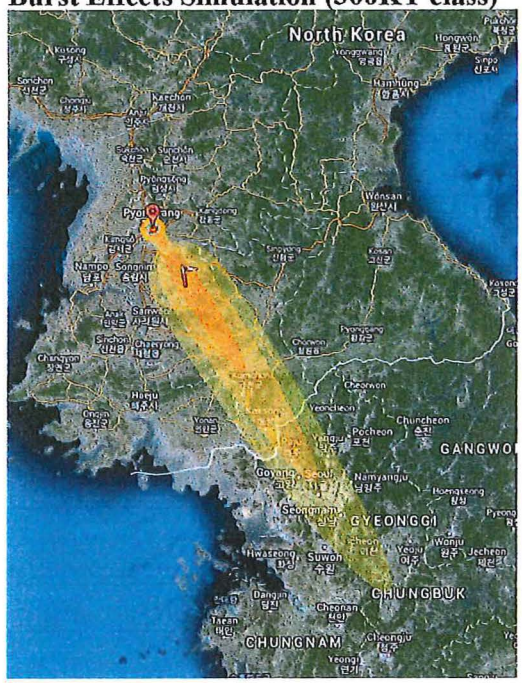
Source: Vick, Charles P. "Weapons of Mass Destruction (WMD)." Sejjil/Ghadr-110. May 13, 2010. http://www.globalsecurity.org/wmd/world/iran/sajjil.htm.

Figure 6 Herman Kahn's Nuclear Escalation Ladder

	31. Reciprocal Reprisals
Exemplary	30. Complete Evacuation (Approximately 95%)
Central	29. Exemplary Attacks on Population
Attacks	28. Exemplary Attacks Against Property
	27. Exemplary Attack on Military
	26. Demonstration Attack on Zone of Interior
	(Central Sanctuary Threshold)
	25. Evacuation (Approximately 70 per cent)
Bizarre	24. Unusual, Provocative, and Significant Countermeasures
Crises	23. Local Nuclear War - Military
	22. Declaration of Limited Nuclear War
	21. Local Nuclear War - Exemplary
	(No Nuclear Use Threshold)
	20. "Peaceful" World-Wide Embargo or Blockade
	19. "Justifiable" Counterforce Attack
	18. Spectacular Show or Demonstration of Force
Intense	17. Limited Evacuation (Approximately 20 per cent)
Crises	16. Nuclear "Ultimatums"
	15. Barely Nuclear War
	14. Declaration of Limited Conventional War
	13. Large Compound Escalation
	12. Large Conventional War (or Actions)
	11. Super-Ready Status
	10. Provocative Breaking Off of Diplomatic Relations
	(Nuclear War is Unthinkable Threshold)
	9. Dramatic Military Confrontations
	8. Harassing Acts of Violence
Traditional	7. "Legal" Harassment - Retortions
Crises	6. Significant Mobilization
	5. Show of Force
	4. Hardening of Positions - Confrontation of Wills
	(Don't Rock the Boat Threshold)
Subcrisis	3. Solemn and Formal Declarations
Maneuvering	2. Political, Economic, and Diplomatic Gestures
	1. Ostensible Crisis

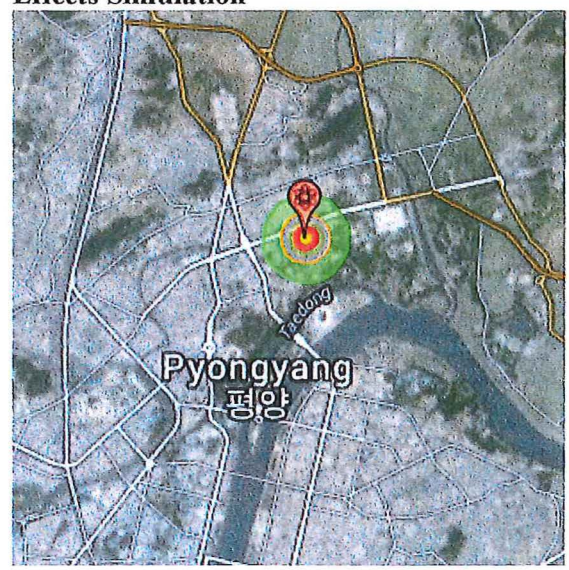
Source: Herman Kahn, *On Escalation: Metaphors and Scenarios* (New Brunswick, NJ: Transaction Publishers, 2010), 39.

Figure 7 MMIII-Surrogate Ground Burst Effects Simulation (300KT class)



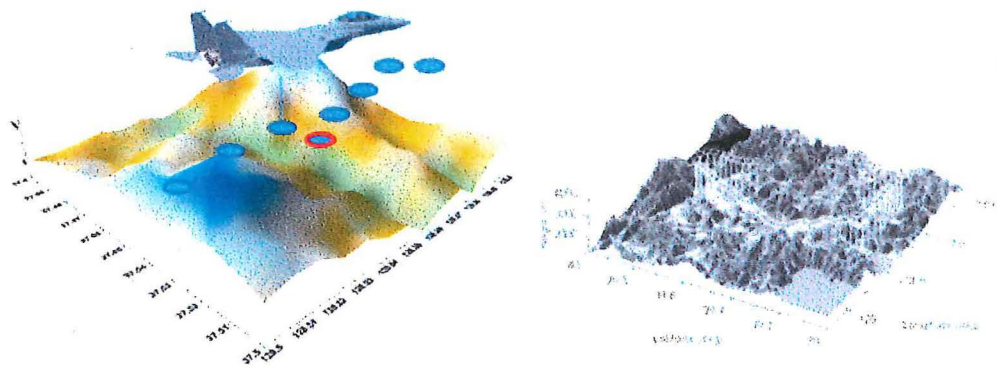
Source: Alex Wellerstein, Nukemap, accessed December 17, 2014, http://nuclearsecrecy.com/nukemap/.

Figure 8 Sub-KT Yield Ground Burst Effects Simulation



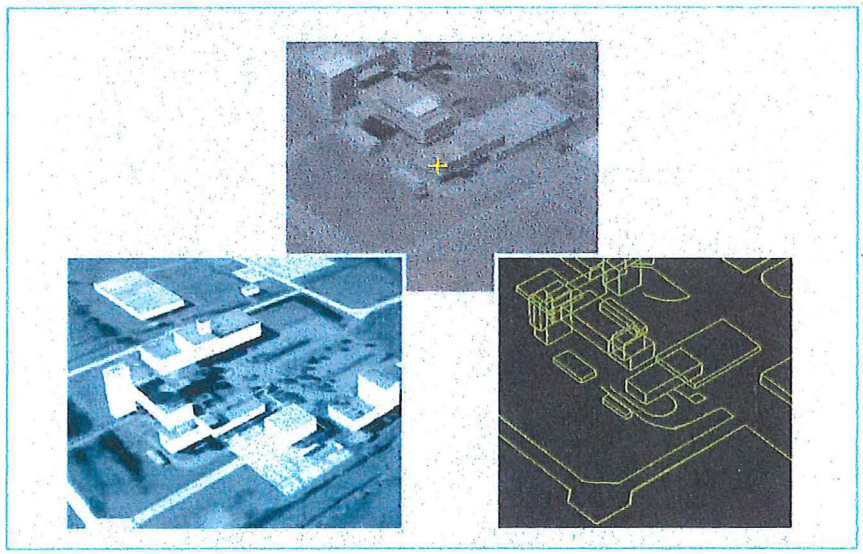
Source: Alex Wellerstein, Nukemap, accessed December 17, 2014, http://nuclearsecrecy.com/nukemap/.

Figure 9 Terrain Aided Navigation (TAN)



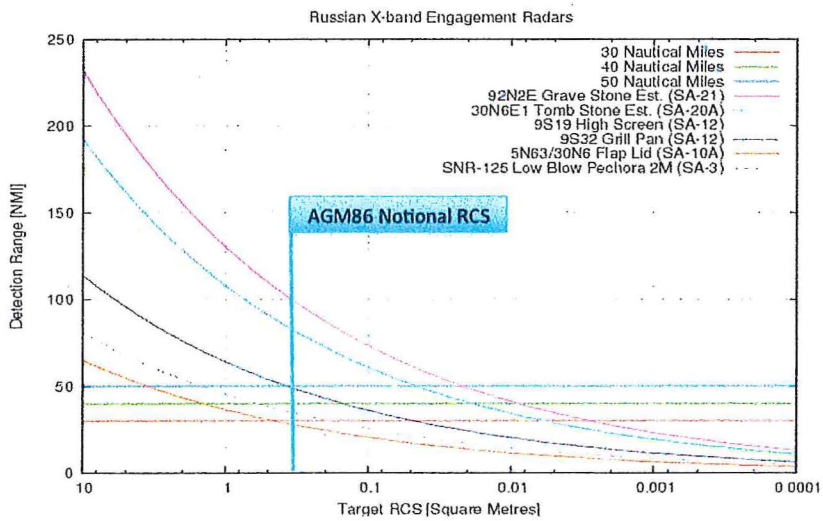
Source: "Terrain-referenced Navigation (TRN) System," Aerospace Systems and Control Lab, section goes here, accessed December 15, 2014, http://ascl.kaist.ac.kr/uav_gnc_08.

Figure 10 Automatic Target Correlation



Source: Joshua Holmes, *JASSM Capabilities and Limitations*, USAFWS Brief (Unpublished).

Figure 11 Open Source Engagement Radar Detection Ranges



Source: "Assessing Joint Strike Fighter Defence Penetration Capabilities," Airpower Australia, January 27, 2014, http://www.ausairpower.net/APA-2009-01-Annex.html.

Figure 12 Common Low Observable Autorouting Example

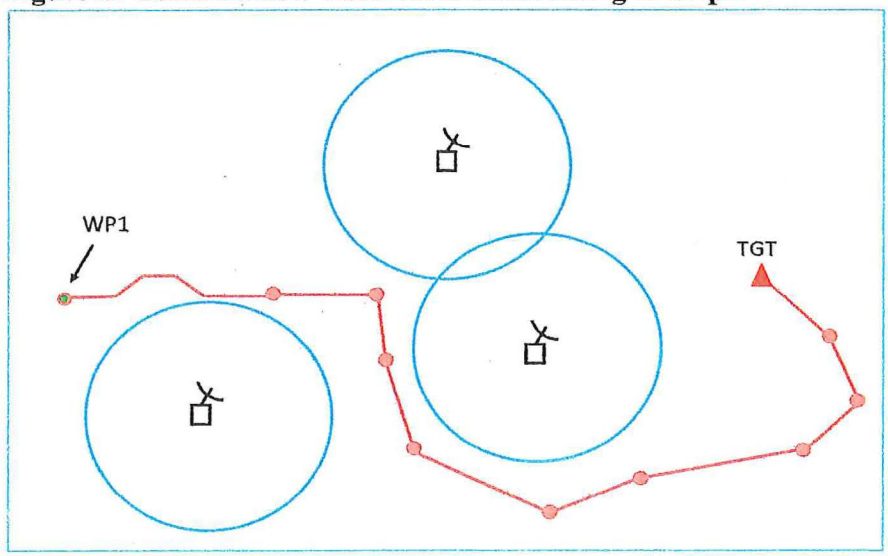
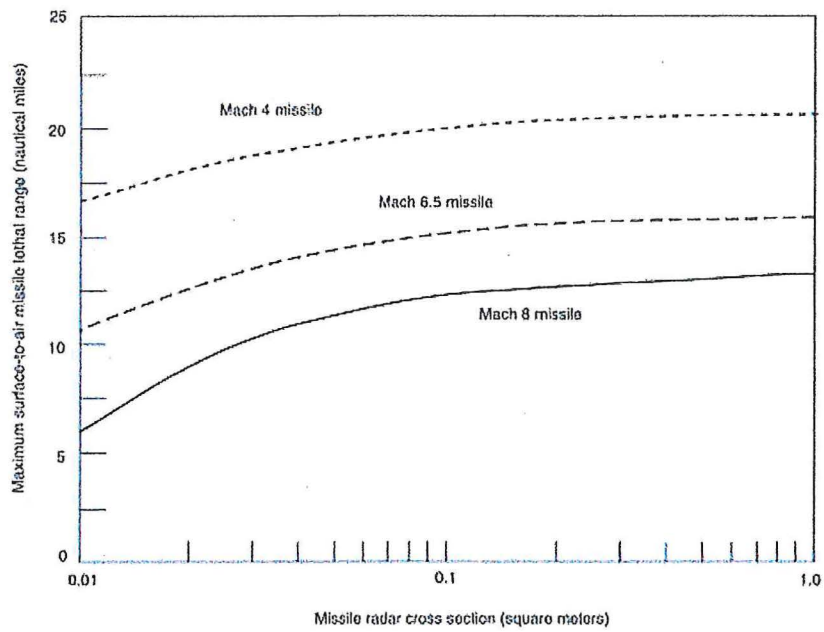
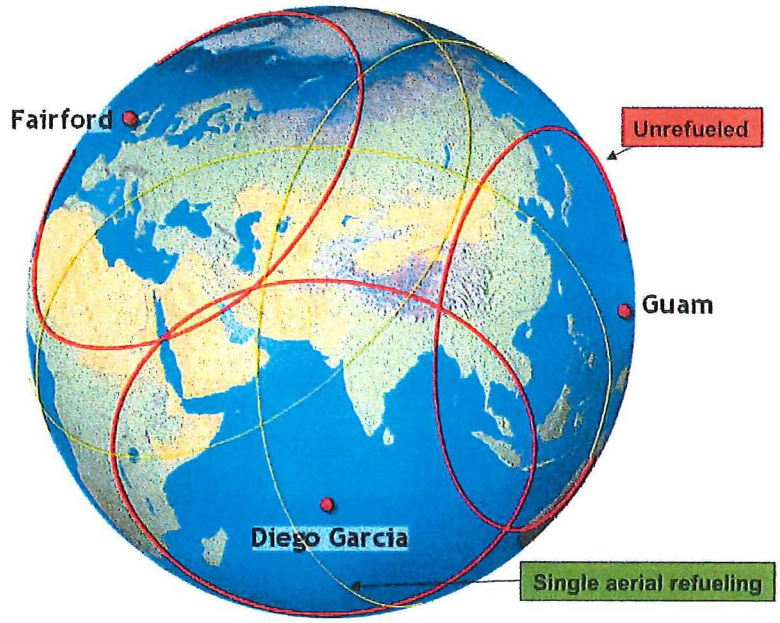


Figure 13 Notional SAM Lethal Range as a Function of Speed and RCS



Source: Review and Evaluation of the Air Force Hypersonic Technology Program (Washington, D.C.: National Academy Press, 1998), 55.

Figure 14 Current Long Range Delivery Platforms



Source: James M. Kowalski, Lt Gen, "Air Force Global Strike Command" (speech, Daedalians Meeting, Columbus Air Force Base, April 2013).