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Assessing The Influence of Hypersonic Weapons on Deterrence

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Preface

During the Academic Year 2019, the U.S. Air Force Center for Strategic Deterrence Studies (CSDS) provided a Deterrence Research Task Force (DRTF) elective for the Air War College and Air Command and Staff College. Seventeen students (11 from the Air War College, six from the Air Command and Staff College) with broad and diverse backgrounds participated in this course, engaging in critical thinking about the nature of strategic deterrence and the role of nuclear weapons under strategic deterrence policy. The class took two field trips. One visited Washington, D.C. to engage with staff in the Office of the Secretary of Defense, Joint Staff, Air Staff, Office of Science and Technology Policy, Defense Intelligence Agency, National Defense University, and the National Nuclear Security Administration. The other field trip was to Lawrence Livermore National Laboratory in Livermore, Calif. to discuss the technical aspects of nuclear weapons.

Dr. James E. Platte, Dr. Paige Cone, and Dr. Lew Steinhoff were the instructors of this elective and faculty advisors for student research. The research questions for this year's DRTF came from U.S. Air Force Global Strike Command and the Deputy Chief of Staff for Nuclear Integration and Strategic Stability (AF/A10) and were divided into two broad themes. First, how can the United States effectively posture in East Asia for a strategic competition with China? Second, how can the United States prepare for a conflict that potentially escalates to an adversary using a low-yield nuclear weapon?

From those two research themes, a selection of the best student research papers was placed into three volumes for publication. Volume I is *Extended Deterrence and Strategic Stability in East Asia*. Volume II is *Non-U.S. Deterrence Strategies: What Must the United States Be Prepared For?* This monograph, *Assessing the Influence of Hypersonic Weapons on Deterrence*, represents the final student research papers.

CHAPTER 1

Introduction

The U.S. Defense Intelligence Agency told Congress in March 2018 that "developments in hypersonic propulsion will revolutionize warfare by providing the ability to strike targets more quickly, at greater distances, and with greater firepower."[1] The notion of hypersonic weapons' ability to "revolutionize" warfare has been at the forefront of most discussions in military and policy circles, particularly in their capacity to change the offense-defense balance by circumventing a country's defense systems.[2] Further, the attention to hypersonic weapons in the media has drastically increased in the past five years, largely in response to fears over the United States falling behind Russia and China in the development of these weapons. In an era of a return to great power competition,[3] there is a growing sense that the United States is losing an already established arms race in hypersonic weapons development based on the frequency and visibility of Russian and Chinese testing. Further, the two adversaries of the United States are reportedly focusing on *nuclear capable* hypersonic weapon delivery systems while the United States is focused on conventional delivery only.

Given the recent uptick in both public and government interest in this weapons system, the 2019 Deterrence Research Task Force took a deep dive into more fully understanding the link between technological innovation and strategic deterrence. Do hypersonic weapons really have the ability to revolutionize warfare? What factors must be present to distinguish a revolution from an evolution in technology and strategy? Is this ability different when we shift our focus to *deterring* warfare? Should it be a priority of the Department of Defense (DOD) to fund and develop these weapons systems?

These questions are taken up by three members of AY2019 Task Force, who examine different angles of how hypersonic weapons may impact deterrence. Together, they result in a more cohesive understanding of hypersonic weapons, and more generally the link between technological innovation and strategic thinking in the United States Air Force.

In Chapter 2, Lieutenant Colonel Nathan Terry begins by exploring how the disparate elements of hypersonic technology – speed, range, and accuracy – compare to those of previous technological innovations. Specifically, he compares hypersonic weapons to intercontinental ballistic missiles (ICBMs) to test whether/how replacing the current ground-launched missile systems with hypersonic weapons would affect deterrence in the context of a limited nuclear war. To do so, he generates a new theoretical construct, the "five-pillar paradigm, (FPP)" that includes five strategies of deterrence and compellence. He then examines each element of hypersonic technology individually, noting how they map to the FPP through historical arguments around deterrence. In doing so, he shows that hypersonic technology represents an evolution in technology rather than a revolution in deterrence thinking. After empirically showing the rate of increase of speed, range, and accuracy across subsequent ICBM introductions to current hypersonic weapons, he then discusses the murkier role of anti-ballistic missile defense systems. Here too, he ultimately finds that these systems are slow to change. Based on this analysis, the colonel finds that replacing ICBMs with nuclear-armed hypersonic weapons are likely to provide limited advantages in both strategies of deterrence and compellence.

In Chapter 3, Colonel (select) John D. Varilek focuses specifically on the role of hypersonics in the relationship between the United States and China, through the question of what, if any, effects to deterrence will these new weapon sets have on U.S.-Sino relations? Colonel Varilek notes that though interest has increased over the past decade, the United States has sporadically pursued hypersonic technology for more than seven decades. In contrast, there is less (publicly available) knowledge about China's program. Colonel Varilek traces the background of both countries' hypersonic weapons programs, nuclear policies, and deterrence postures. He then examines the potential effects of hypersonic systems on deterrence based on the type of delivery platform to be utilized. Ultimately, he finds that hypersonics have the ability to revolutionize the "technological toolkit" of both militaries, but that the effects of the weapons on deterrence will be negligible. The current status quo stability is likely to remain since both countries are pursuing the technology successfully.

Finally, in Chapter 4, Major Jeffrey Hill explores the impact to the deterrence status quo of the United States, Russia, and China all pursuing hypersonic weapons systems. He begins with the premise that the technological development alone will not significantly affect the status quo. Rather, the potential for misperception by any of the three countries towards another's intentions for developing hypersonic technology may have a significant and negative effect on the status quo. Major Hill begins with an overview of historical developments in hypersonic technology, lays out his hypotheses and research design, and then analyzes the three major powers' current deterrence postures. After laying out current postures, he discusses the potential challenges that hypersonics could pose, and outlines each country's perceived need for such weapons systems. This culminates in an analysis of whether hypersonics are destabilizing, where Major Hill ultimately finds that the lack of understanding of great nuclear powers' intentions regarding hypersonic weapons has the most potential to destabilize the status quo and lower the threshold for the use of nuclear weapons.

The book concludes with general implications and policy recommendations from the researchers.

Notes

1. Lt. Gen. Robert Ashley, “Statement for the Record: Worldwide Threat Assessment,” (March 6, 2018), www.dia.mil/News/Speeches-and-Testimonies/Article-View/Article/1457815/statement-for-the-record-worldwide-threat-assessment.

2. Heather Venable and Clarence Abercrombie, “Muting the Hype over Hypersonics: The Offense-Defense Balance in Historical Perspective,” (May 28, 2019), warontherocks.com/2019/05/muting-the-hype-over-hypersonics-the-offense-defense-balance-in-historical-perspective.

3. Ibid.

CHAPTER 2

The Utility of Replacing U.S. ICBMs with Nuclear-Armed Hypersonic Weapons Systems

Lieutenant Colonel Nathan Terry, U.S. Air Force

In 1945, the world jolted into the nuclear era when technology amplified bomber payloads 700-fold.[1] Even though nuclear weapon and bomb delivery technology increased through decades of peace and war,[2] this incredible discontinuity of capability changed the way nations jockeyed for power on the international stage. American analysts replied to this massive technology investment by introducing the theory of nuclear deterrence with the argument that the military's main purpose was preventing war by protecting a state's ability to retaliate.[3] Generations of strategists contributed to the evolution of deterrence theory as immense changes in technology catalyzed changes in the deterrence paradigm. For example, the conjunction of nuclear weapons technology with missile technology spurred nuclear deterrence thinkers to develop the theory of mutually assured destruction.[4]

Intercontinental ballistic missiles (ICBMs), defined as missiles with a range of greater than 5,500 miles, were initially viewed as a low-cost way to deter the Soviet Union from attacking the United States and its allies.[5] The threat of a nuclear response to large-scale aggression was viewed as a form of deterrence. However, individual nuclear missiles were vulnerable to attack. Fears a Soviet first strike could eliminate the U.S. second-strike capability prompted the United States to grow its nuclear arsenal large enough to make it unlikely the Soviet Union could destroy the entire United States second-strike capability.[6] There was a belief that "the rocket would always get through."[7] While ballistic missile defense (BMD) technology challenges this assertion, hypersonic delivery technology threatens to reinstate it.

Hypersonic technology, commonly defined as systems capable of traveling faster than Mach 5,[8] combines the maneuverability and accuracy of cruise missiles with the long range and speed of ICBMs.[9] The combination of speed and range makes hypersonic weapons suitable for conventional missions characterized by a fleeting window of opportunity, i.e. missions like destroying high-value mobile targets.[10] Furthermore, combining maneuverability and speed may make hypersonic weapons systems less vulnerable to BMD than ICBMs.[11]

While current U.S. hypersonic development programs focus on delivering conventional munitions,[12] China and Russia are both developing their own hypersonic technology and other countries may eventually follow.[13] Some nations are developing nuclear-armed hypersonic weapons systems (NAHWS).[14] As the technology landscape evolves, the United States needs to reassess its own technology relative to other nations competing in the strategic environment. This may prompt the United States to reassess its thinking about its nuclear deterrence posture, especially as the United States modernizes its nuclear forces.[15] This paper uses the framework of nuclear deterrence to consider the impacts of replacing the ICBM force with NAHWS.

Background

The current U.S. nuclear arsenal is composed of three distinct legs: bombers, submarine-launched missiles, and ICBMs. Deploying bombers is a widely acknowledged form of signaling and a bomber's ability to be recalled after launch is useful in flexible escalation.[16] The submarine-based leg of the nuclear triad is highly survivable[17] and can promptly strike many targets.[18] The ICBM leg is the least expensive leg of the triad,[19] but its fixed locations leave ICBMs vulnerable to attack.[20] Despite increasingly hardened silos, improved missile accuracy makes ICBM forces ever more vulnerable to strikes with low-yield nuclear weapons[21] and possibly even conventional attack.[22] Furthermore, ICBMs in flight are potentially vulnerable to BMD systems.

While the various legs of the nuclear triad are distinct, they are complementary in that advances or limitations in one leg often catalyzes changes in other legs. For example, limitations in early bomber technology combined with improvements in missile component technology to make ICBMs a viable nuclear delivery system. ICBM technology focused on increasing survivability and accuracy. Improvements in accuracy increasingly threatened the survivability of targets, motivating the development of BMD technology as a defensive response. This section examines historical changes in ICBM and BMD technology as a way to better gauge the potential impacts of future hypersonic technology.

The need for long range nuclear delivery systems came into sharp focus in 1945. The B-29 bomber had a 3,000-mile range[23] and early bomber technology development focused on tradeoffs between survivability and range. Configurable wing design technology allowed aircraft to switch between fuel efficient high altitude flights over friendly territory and less risky low altitude flights over enemy territory.[24] The development of contour-matching navigation systems combining inertial guidance and radar technology enabled low-altitude flights.[25] Air-launched cruise missiles supported stand-off attacks by bombers and small engine technology increased effective missile ranges.[26] New materials allowed higher engine operating temperatures, which in turn increased fuel efficiency and range.[27] Soviet advances in radar, command and control, and fighter technology further threatened bombers, driving requirements for improved missiles.[28]

Early missiles were inaccurate,[29] so technological improvements were a priority. By 1954, high precision inertial components, transistors capable of supporting onboard navigation computers, and the technology for miniaturized nuclear weapons advanced far enough for long range missiles to serve as viable delivery vehicles for nuclear weapons. This prompted President Dwight Eisenhower to prioritize ICBM development.[30] Missile accuracy is defined in terms of circular error probability (CEP), the range described by a circle within which a missile has a 50-percent probability of striking.[31] Simple geometric arguments show increasing weapon accuracy by a factor of two is functionally equivalent to increasing yield by a factor of eight.[32] The development of smart fuses allowed weapons to dynamically vary the altitude of detonation in order to compensate for off-course trajectories, increasing the probability of a successful ICBM strike.[33] To compensate for limited accuracy, military planners considered striking targets with multiple weapons. Rapidly retargetable missiles decreased the need for this redundancy,[34] effectively reducing the number of nuclear weapons required for a first or second strike~~s~~.

More accurate ICBMs potentially threatened the survivability of an adversary's ICBM force.[35] In 2017, Keir A. Lieber and Darryl G. Press described the tradeoffs associated with several modes of increasing ICBM survivability, including hardening, redundancy, concealment, and mobility.[36] More accurate delivery systems thwart hardening[37] and concealment is increasingly being offset by increased intelligence, surveillance and reconnaissance (ISR) capabilities.[38] Survivability can be bolstered by anti-BMD systems.[39]

As ICBMs grew in number and sophistication, technology to defend against them developed in tandem. Attrition of the earliest long-range missiles, German V-1 rockets, reached almost 95 percent once proximity-fused anti-missile weapons were developed.[40] The V-2 rocket was 10 times faster and was nearly impervious to attack.[41] Early nuclear cruise missiles, such as the Snark, were also highly vulnerable to anti-aircraft fire.[42] After the sinking of an Israeli destroyer by cruise missiles in 1967, the United States began to develop anti-missile ship defenses.[43] Air defenses motivated Britain to move from a bomber-based nuclear force to a missile-based nuclear force.[44] Congress authorized the first American BMD system in 1969.[45] Multiple independently targeted reentry vehicle (MIRV) systems packing multiple warheads onto a single missile are one possible response to BMD technology.[46]

BMD systems are extremely complicated.[47] Just as there are many types of missiles each with its own combination of vulnerabilities and defenses, there are multiple types of BMD systems, each a complex collaboration of sensors and shooters. Coordinating between system elements presents huge technical challenges, especially for targets defended by layers of BMD systems. The exact details of system effectiveness are complex, scenario specific and highly classified. Considering these complexities, rather than analyzing BMD systems in detail, this paper examines the implications of deterrence posed by the capability of BMD to counter small salvos of missiles in a limited war.[48]

Hypersonic vehicles are commonly referred to as systems that travel at least Mach 5.[49] James Acton explains there are two main types of hypersonic systems: hypersonic cruise missiles and hypersonic boost-glide missiles.[50] In this paper, the word hypersonic generally refers to these two systems.[51] Hypersonic cruise missiles are similar to traditional cruise missiles, except they are much faster. Boost-glide weapons launch from one missile, which subsequently releases a maneuverable glide vehicle. The term "maneuverable" distinguishes between the highly predictable flight paths of ballistic systems and the variable flight paths of cruise missiles. Currently, the United States, Russia and China are all actively working to develop advanced hypersonic systems. Other countries are interested as well. Public reports describe U.S. hypersonic development in terms of conventional systems capable of providing a prompt, long-range strike capability. By contrast, Russian hypersonic technology may be geared towards nuclear weapons.

While Acton recognizes hypersonic systems as a potential "left of launch" form of BMD,[52] hypersonic weapons are not necessarily invulnerable.[53] For example, hypersonic glide vehicles may slow down after launch, making them more vulnerable to missile defense, but it may be possible to mitigate this risk by increasing the hypersonic weapon's initial launch velocity.[54] Hypersonic gliders traveling through the atmosphere may be unable to effectively deploy decoys.[55] Also, they may generate considerable heat through friction, making it possible to track them.[56] Early-warning satellites capable of spotting ICBMs may give useful warnings about hypersonic weapons,[57] perhaps 30 minutes in the case of boost-glide weapons and up to 15 minutes for hypersonic cruise missiles.[58] Hypersonic weapons reliant on Global Positioning System (GPS) navigation may be vulnerable to jamming or attacks on the GPS constellation,[59] meaning their dependence on ISR for targeting may make them vulnerable to local ISR degradation.[60]

In the same way bombers prompted the development of missiles and just as missiles provoked the development of better missiles and anti-missile technology, hypersonic technologies will continue to advance in ways that catalyze changes in other forms of military technology. Likewise, improvements in ICBM and missile technology spurred theoretical developments in deterrence and compellence. The next section focuses on these advancements and considers how future NAHWS may be described by existing ideas about deterrence and compellence.

Theory

The incredibly destructive power of nuclear weapons led a number of scholars to consider nuclear bombs as weapons useful for much more than fighting wars. Nuclear weapons could be used to deter adversaries from attacking or to compel adversaries to provide concessions. While much of this theory focused on averting surprise nuclear attacks, this section describes how deterrence and compellence have been theorized to operate in the context of a limited war because BMD is most credible in scenarios involving limited numbers of ICBMs. After defining, describing and distinguishing between the concepts of deterrence, compellence, and defense in the context of a limited war scenario, this section describes how these concepts might be used to describe the potential roles of ICBMs and BMD in a limited war.

Deterrence

Early deterrence thinkers' horrified fascination with the destructive power of nuclear weapons convinced them nuclear war must be avoided. Glenn H. Snyder conceived of deterrence as a means to avert aggression, either because conventional forces rendered offense futile or because nuclear retaliation made attempts at belligerence akin to suicide. Ultimately, Snyder echoed Bernard Brodie's belief that nuclear weapons were too destructive for anything but deterrence.[61] Thomas C. Schelling also viewed nuclear war as horrifically destructive because nuclear weapons not only threaten pain, but potential extinction.[62] Of nuclear bombs, Schelling said, "they hurt, and promised more hurt and that was their purpose."[63]

In Schelling's mind, this power to hurt provided tacit and explicit bargaining power central to the escalation and eventual termination of military conflicts.[64] The risk of nuclear punishment is central to the idea that an adversary can be deterred from using nuclear weapons of their own. Risk or uncertainty in a potential nuclear response is sometimes judged strategically useful.[65] Furthermore, because nuclear devastation could be rained down upon either side of the conflict at any time in the war, winning was no longer the ultimate protection against losing.[66] Lawrence Freedman succinctly characterized deterrence by denial as removing "strategic options" from the adversary, whereas deterrence by punishment gave the adversary "powerful incentives to choose in a particular way."[67] The belief that nuclear weapons are so devastating that nuclear strikes must be avoided at almost any cost is central to deterrence.

Compellence

Robert Anthony Pape agreed that the awesome destructive power of nuclear weapons made nuclear threats a potent weapon "tantamount to genocide,"[68] implying nuclear weapons had little utility to destroy an adversary's military forces.[69] Instead, Pape focused on leveraging "civilian vulnerability" as a means to gain concessions without having to pay the costs of completely destroying adversary forces in a full military victory.[70] From the perspective of the coerced, compellence succeeds when the costs of resisting the coercer exceed the benefits of resisting.[71] Compellence considers the conditions under which concessions can be acquired while still keeping the war limited.

Pape describes three modes of compellence: compellence by denial, compellence by punishment, and compellence by risk.[72] First, compellence by denial focuses on using military means to degrade an adversary's military capabilities in the hopes of gaining concessions without completely defeating the enemy.[73] This differs from a purely military victory largely as a matter of degree and relative cost. While Pape and others argued that the military potential of nuclear weapons paled in comparison to the dreadful destructive potential against civilian targets,[74] Herman Kahn and others saw nuclear weapons as a potentially effective means of "counterforce operations," as opposed to only using them for punishing operations against cities.[75] Increasing the accuracy of ICBMs may provide a means to leverage the destructive power of nuclear weapons and provide military utility without genocidal collateral damage. If NAHWS can couple the speed and range of ICBMs with the accuracy of cruise missiles, NAHWS may have a role for nuclear compellence by denial.

Second, Pape refers to compellence by punishment as inflicting massive harm, primarily on the civilian population in the hope that mechanisms like revolt or social disintegration will force adversary governments to sue for peace.[76]

Deterrence by punishment seeks advantage through threats of massive violence, whereas compellence by punishment seeks advantage by applying massive violence to civilian populations. Third, Pape describes compellence by risk, in which punishment is incrementally and increasingly inflicted, with the expectation that the mechanism of "avoiding future costs" will convince the adversary to grant concessions.[77] To Pape, the canonical example of compellence by risk was the Rolling Thunder campaign of the Vietnam War where the United States hoped a gradually intensifying bombing campaign would compel its adversaries to negotiate.[78] Pape was critical of compellence by risk on the grounds that once punishment occurs, the same punishment can no longer be threatened again.[79] For example, after a nuclear attack, there are less things to damage with a follow-on attack.

Credibility in the FPP is a continuum, with some pillars requiring more credibility than others. While threats require credibility to be effective, preemption requires less credibility. For example, deterrence by punishment requires a credible threat to be effective. Compellence by risk likewise operates by threatening future hurt and therefore also requires significant credibility. Compellence by denial coerces military forces to surrender before they are completely destroyed, strongly implying a credible threat. Threatening to destroy civilian populations to gain concessions requires credibility to qualify as a useful compellence by punishment strategy.

However, a compellence by punishment strategy that inflicts massive destruction on civilian populations and then awaits the inevitable collapse requires less credibility. Effective deterrence by denial via preemptive strikes also requires less credibility because credibility cannot influence adversary choices if all of their choices have been eliminated. On one hand, convincing an adversary its attack is doomed to failure may qualify as a deterrence by denial strategy requiring credibility. On the other hand, acting on judgments of military capability is routine part of warfighting and convincing an adversary not to attack may be less about deterrence and more about defense.

Defense

Patrick M. Morgan argued that defense and deterrence "are analytically distinct, but effectively inseparable in any practical sense."[80] Defense, the "capability of resisting attack,"[81] is the opposite of offense. Snyder defined defense as a means of reducing the prospective costs of a conflict[82] and argued that military forces are simultaneously valuable for defense and deterrence.[83] ICBMs and BMD are examples where the line between defense and deterrence is blurred. On one hand, the former can be used to attack military targets while the latter can be used to protect military targets. These actions qualify as offense and defense. On the other hand, using an ICBM to threaten a city can be a form of deterrence by punishment or compellence by punishment. Therefore, using BMD to protect ICBMs potentially involves deterrence. While arguments about ICBMs and BMD can qualify either as deterrence, compellence, or defense, this paper focuses on the deterrence and compellence implications rather than considering defense questions about how well the systems might perform in combat operations.

Deterrence and Compellence in Limited War

Schelling defined limited war as a conflict characterized by "preoccupation with the violence held in reserve."[84] Instead of using military force to decide the outcome of the war, both sides in a limited war are also bargaining over the methods of the conflict.[85] The methods in question revolve around nuclear weapons, whether to use them, how many to use, what targets to use them against, etc. Schelling viewed limited war in terms of an active bargaining session between both sides over these terms. There is a risk one side could introduce a nuclear weapon, an act that would immediately transform the war into something new.[86] Managing the negotiation of dares, threats, and demonstrations becomes the primary focus for leaders of both sides.[87] For example, the first nuclear attack on a city may be viewed as a proposal for the rules governing future attacks rather than only as a military action against a specific target.[88] Kenneth N. Waltz questioned whether or not unconditional surrender is possible when negotiating with a nuclear-armed adversary.[89]

Due to the nature of this negotiation, Schelling argued that deterrence still functions even in war.[90] A nation could use deterrence by denial to make nuclear escalation impossible or a nation might rely on deterrence by punishment to discourage an adversary from attempting nuclear escalation.[91] So long as there is sufficient hurt held in reserve to "make the enemy behave" (or so long as the adversary believes there is), deterrence by punishment and compellence by punishment are arguably active inside a nuclear conflict.[92] Using compellence by denial to gain concessions without winning a total war smacks of limited war, as does the controlled use of force characteristic of compellence by risk.

Schelling identified three types of limited war.[93] The first was a general military engagement limited in geography and means (i.e. the Korean War). The second was a form of nuclear brinksmanship (i.e. Cuban Missile Crisis). The third was a war of hurt directed at the civilian population in the hopes the country would capitulate (i.e. Vietnam War). In each scenario, nuclear weapons were held in reserve, as an implied or explicit threat, making the conflict a limited war.

Schelling makes three observations about how nuclear weapons impact limited wars.[94] First, if both sides have nuclear weapons, as the battle ebbs and flows, even the losing side may be able to seriously harm the winning side. Winning does not always save a country from damage or even from being annihilated. Second, Schelling points out that nuclear weapons make noncombatants a central target of the power to hurt. Again, this means the losing side may lash out with any remaining nuclear weapons and attack adversary cities. Third, Schelling argued that self-imposed limits on wars destructiveness was a form of deterrence active during previous wars. He points to limits on gas attacks in World War II as an example. This emphasizes the argument that deterrence operates during wartime, either by discouraging a conventional war from escalating to a nuclear war, or by discouraging a limited nuclear war from evolving into a conflict involving ever more, ever larger nuclear weapons. However, as additional nuclear weapons are employed, the power to hurt decreases, if for no other reason than there are fewer potential targets. Deterrence in a limited war does not lose its potential utility immediately after the first nuclear weapon is used. Instead, deterrence and compellence may lose their power rapidly or slowly, depending on the exact conditions of the geopolitical scenario and how the war unfolds.

In summary, the concepts of deterrence by punishment, deterrence by denial, compellence by punishment, compellence by denial, and compellence by risk describe arguments about how nuclear weapons and defenses against nuclear weapons may operate in a limited war. For convenience, these five concepts of deterrence and compellence will be referred to as the five-pillar paradigm (FPP). Defense being relevant, but not central to deterrence and compellence, is not explicitly considered a pillar of the FPP. The rest of the paper considers whether or not the FPP can encompass the arguments made about the potential role of ICBMs and BMD for deterrence and compellence in a limited war. These arguments are analyzed in terms of three specific hypotheses:

***Hypothesis Number 1*:** *NAHWS represent an evolution in deterrence thinking rather than a quantum leap.*

***Hypothesis Number 2*:** *NAHWS are better described as a technological evolution relative to ICBMs than as a technological quantum leap.*

***Hypothesis Number 3*:** *NAHWS do not provide a significant U.S. advantage for nuclear compellence relative to ICBMs.*

Research Design

This section outlines tests for each of the three hypotheses laid out above, beginning with the first hypothesis that NAHWS represent an evolution in deterrence thinking rather than a quantum leap. If the roles of ICBMs and BMD in limited wars can be described by the FPP, then the impact or utility of future NAHWS in a limited war may also be describable using the FPP. This possibility is labeled an evolution in deterrence thinking. If ICBMs and BMD are incompatible with the FPP, then NAHWS may not be easily described with the FPP either. This possibility is labeled a quantum leap in deterrence thinking because analyzing the utility or impact of future NAHWS in a limited war may require significant modifications to existing arguments about deterrence and compellence.

The analysis considers arguments about the utility of BMD and ICBMs for each pillar of the FPP. Arguments were selected based on their relevance to a limited war scenario. Deterrence arguments will be examined by studying publications by authors such as Brodie, Schilling, Kissinger, Freedman and others. A collection of essays edited by Ashton Carter arguing for and against BMD form the primary source for discussions of BMD. ICBMs are analyzed by reviewing arguments for and against maintaining and modernizing the ICBM force. Each argument is classified according to which of the pillars of the FPP to which it is relevant.

Hypothesis Number 1 assumes if ICBMs and BMD can be described by the FPP, NAHWS can also be described by the FPP. *Hypothesis Number 2*, NAHWS are better described as a technological evolution of ICBMs than as a technological quantum leap*,* explores how technological changes may limit the validity of this assumption. If the technological capabilities of ICBMs can be described by the FPP even though capabilities changed over time, then the FPP may be robust relative to changes in technology. However, if technological capabilities were relatively fixed, this suggests caution in applying the FPP to hypersonic systems with significantly improved capabilities relative to ICBMs. In both cases, examining the reasons for changes in technology should illuminate potential limitations of the FPP.

Hypothesis Number 2 examines the historical evolution of ICBM technology in terms of three critical parameters relevant to NAHWS: speed, accuracy, and range. Speed is germane because NAWHS are by definition fast and concerns have been raised about how faster nuclear weapons may impact deterrence by decreasing missile warning times.[95] Furthermore, their high speed makes hypersonic systems challenging for BMD systems.[96] Range is a canonical property of ICBMs – it was a primary motivation that distinguished them in importance from bomber-based nuclear delivery platforms. Increasing range is an important component of emerging hypersonic conventional weapons.[97] Lastly, increased accuracy decreases the risk of collateral damage by allowing smaller nuclear warheads to accomplish missions. Hypersonic delivery systems promise significant accuracy,[98] therefore, it is useful to examine the historical evolution of ICBM accuracy.

Dietrich Schroeer judged bomber technology development to be "more evolutionary than revolutionary" based on graphs of key parameters over time.[99] This section examines whether ICBMs are an evolution or a quantum leap using a similar methodology. A quantum leap corresponds to an order of magnitude change on the scale of one year. Anything less than that is a technological evolution. A factor of 10 will be the dividing line between a quantum leap and evolution.[100]

ICBM data comes from two sources: "The U.S. Missile Data Book, 2012,"[101] which contains speed, range, and initial operating capability (IOC) and "Science, Technology and the Nuclear Arms Race,"[102] which contains accuracy. ICBM technology capability data for this period is publicly available as are discussions about deterrence and compellence. Strategic nuclear delivery systems similar to ICBMs in terms of range, promptness, and potential vulnerability to BMD systems will also be considered, i.e. submarine-launched ballistic missiles (SLBMs) and foreign ICBMs. This study is limited by the availability of relevant data. NAHWS have not been openly fielded and little definitive unclassified technological capability data exists. BMD systems consist of a number of complex elements whose performance is highly scenario dependent.[103] Performance parameters may be significantly classified. Not directly considering the evolving technological capability of BMD is a limitation of this study.

This paper defines a limited war as an armed conflict between the United States and an adversary possessing nuclear weapons, a conflict in which nuclear weapons have either not yet been employed, or a conflict where nuclear weapons have only been employed in a limited way.[104] Limited war does not end immediately after the first nuclear weapon is used. The term "limited war," while deliberately ambiguous in order to capture the range of situations under which nuclear deterrence can operate during a limited war, contains five key assumptions.

First, this analysis assumes both sides consider using ICBMs in small enough numbers to make BMD a significant consideration in launch decisions. Second, it assumes nuclear weapons are held in reserve by both sides. Third, it assumes both sides have significant interests (fielded forces, industrial centers, or population centers, etc.) to protect. Fourth, it assumes the United States is trying to prevent an adversary from launching nuclear attacks on the United States (or its allies) during this conflict. This assumption envisions immediate deterrence rather than generalized deterrence.[105] Fifth, both sides are presumed to start the limited war with some BMD capability, although this capability is not assumed to remain static during the conflict. The uncertainty of nuclear escalation in a limited war presents significant risks to analyzing a single scenario or even a class of scenarios. The details of how the conflict will unfold are uncertain and the exact risks are impossible to accurately quantify. Instead, this analysis focuses on general trends.

Hypothesis Number 3, NAHWS do not provide a significant U.S. advantage for nuclear compellence relative to ICBMs, examines the potential utility of NAHWS relative to the potential utility of ICBMs in terms of each pillar of the FPP. The utility of BMD (and by extension the utility of NAHWS) is analyzed in a similar manner. The risk a conventional attack is confused with a nuclear strike (warhead ambiguity)[106] and the risk a country mischaracterizes an attack on a neighbor as an attack on itself (destination ambiguity)[107] are also considered in terms of the relative level of risk posed by other legs of the nuclear triad.

Analysis

Hypothesis Number 1

This section considers how BMD and ICBMs can be described by each of the concepts of the FPP. If each pillar can be used to describe ICBMs and BMD in terms of compellence and deterrence, then ICBMs and BMD are judged to correspond to an evolution of deterrence, suggesting the FPP can describe how future NAHWS might impact deterrence thinking. If the FPP cannot describe arguments made with regard to ICBMs and BMD, significant changes in deterrence theory may be required to understand how NAHWS may impact international relations. A significant potential limitation of this conclusion is considered by *Hypothesis Number 2*.

Deterrence by Punishment

Deterrence by punishment expects an adversary will remain passive due to fear of massive reprisals and suggests this fear may serve to limit the risk of escalation during war.[108] BMD has also been posited to play a role in deterrence by punishment. For example, George Schneiter argued that BMD may make a first strike less ominous and therefore more likely.[109] He continued the argument by postulating if a first strike is less threatening, then a massive counterstrike is less proportional and therefore less credible, making a first strike even more likely.[110] Deterrence by punishment is consistent with Kahn's Type I and Type II deterrence where nations threaten massive retaliation in order to dissuade adversaries from directly attacking them or their allies.[111]

Deterrence by Denial

ICBMs have been postulated to serve as a form of deterrence by denial in two ways: massive size and intentional hardening. The "sponge theory" of ICBMs postulates ICBMs protect other nuclear forces by soaking up the initial first strike.[112] Snyder dismisses the nuclear sponge argument on the grounds that Soviet nuclear forces are too massive for the sponge to be effective.[113] This suggests the sheer size of the ICBM force may be either a form of deterrence by denial or defense. Techniques such as hardened silos, dispersed missiles, mobile launchers, and launch on warning postures are forms of negating the advantages of ICBMs. Incorporating MIRV systems into ICBMs potentially thwart hardened targets.[114]

First strikes by ICBMs are more difficult to classify. A preemptive first strike that successfully destroys or disables the adversary's entire ICBM force constitutes deterrence by denial because the adversary no longer possesses an attack option. If the adversary has enough ICBMs to launch a counterattack, but decides to surrender rather than risk its remaining weapons in a continued conflict, the first strike might better be classified as compellence by denial. If the attack simply reduces the number of ICBMs possessed by the enemy, leaving it with a reduced nuclear attack capacity, this may be better characterized as "normal" warfighting or defense. Freedman defined an attempt to weaken an adversary's overall military capability as preventative war. Preemptive actions focusing on degrading specific adversary capabilities serve a similar function.[115]

BMD is also hard to classify as deterrence, even though some scholars have done so.[116] On one hand, once a BMD system is deployed, the defender waits for the attack rather than taking the initiative and this passive stance is more consistent with deterrence than compellence. If the attacker only possesses a small number of ICBMs or if BMD is believed to be 100 percent effective, BMD may be accurately classified as deterrence by denial. Carter and others argued that the impact of BMD on deterrence depends on whether it is protecting military forces or civilian populations.[117]

On the other hand, Freedman referred to BMD as a form of defense.[118] From the point of view of an attacker with hundreds of ICBMs, BMD may be just one more potential risk to an ICBM, similar to the risk of an ICBM suffering mechanical difficulties or otherwise failing to destroy its target. Furthermore, completely effective BMD is difficult for large countries because there are so many potential targets and not defending them all leaves exploitable gaps.[119] Therefore, BMD resembles defense more than deterrence by denial.

Compellence by Punishment

The incredible destructive potential of a salvo of ICBMs suggests destroying a few cities, or even whole areas within cities, may create enough destruction to collapse the opponent's government through revolt or social disruption.[120] After collapsing, the adversary's government will be unable to deny concessions, even though some cities or military forces may remain. Threating destruction to gain concessions is arguably another form of compellence by punishment. This differs from deterrence, which leverages threats of punishment to avoid wars. While massive nuclear strikes don't fit neatly under the umbrella of limited war, there is always a potential that one side could judge it advantageous to rapidly widen the limited war into Armageddon.

Former Secretary of State Henry Kissinger argued that if a country possesses a solid defense against nuclear retaliation, it has a significant incentive to make a first-strike attack on its enemy.[121] In the words of Waltz, "the shield makes the sword usable."[122] Carter argued this is especially true if BMD can only handle limited nuclear salvos because after a first strike, an adversary's second-strike capability will be too small and uncoordinated to provide anything other than a "ragged" response, and thus be easily negated by the aggressor's BMD systems.[123] Schneiter took a different tact by suggesting because BMD makes first strikes less likely to succeed, first strikes are less ominous and therefore more likely.[124] However, these arguments assume BMD is believed to be highly effective against large salvos of missiles which may not be the case.

Compellence by Denial

Using a nuclear weapon to destroy key conventional forces, nuclear forces or even key elements of a military industrial base in hopes the adversary will offer concessions constitutes compellence by denial.[125] The winning side may use nuclear weapons to hasten conventional victory or the losing side may use nuclear weapons to reverse conventional defeat.[126] Either case may constitute compellence by denial because each side is trying to gain concessions without fully defeating an adversary's conventional military forces.[127] Treating nuclear weapons as big conventional bombs useful for achieving military victory resembles defense, emphasizing the idea that compellence by denial is part of a continuum, with nuclear attacks at the extreme end. Kahn's Type III deterrence includes a spectrum of activities consistent with compellence by denial.[128]

Arms races associated with BMD, MIRVs and ICBMs can also be framed in terms of compellence by denial because contests over parity (technological or numerical) attempt to mitigate relative adversary military capabilities and gain concessions without completely destroying an adversary's forces.[129] Leveraging a BMD system to gain concessions during an arms control discussion is also arguably a form of compellence by denial. Colin Gray argued that arms races are largely futile because as one side gains a technological advantage, the other side develops a counter. While supportive of pursuing technological changes such as BMD, Gray remained unconvinced that technologies such as BMD would fundamentally alter the principles of deterrence because each technological advance would eventually be countered by the adversary.[130] Kissinger argued along the same lines in 1957 when he pointed out ICBMs could already travel 5,000 miles in less than half an hour and concluded more speed increases would only provide marginal increases in military capability.[131] On the other hand, temporary technological advantages might yield longer-term advantages in arms control negotiations.

Compellence by Risk

Pape's definition of compellence by risk includes conventional wars escalating with the implied or explicit threat of nuclear attack if concessions are not made.[132] In such a scenario, the pain inflicted by conventional war is a promise of additional pain in the near future. There is danger that the escalation will not go as planned and instead spiral out of control.[133] ICBMs may be effective for compellence by risk in cases where nations employ limited nuclear weapons while intentionally holding long-range nuclear weapons (i.e. ICBMs) in "reserve."[134]

Summary

Table 1 summarizes how arguments about ICBMs and BMD can be encompassed by the FPP.[135] Most pillars of the paradigm describe arguments about how weapon systems increase or decrease the likelihood of a first strike, probably reflecting how fears of a nuclear "bolt from the blue" preoccupied many deterrence thinkers. Since ICBMs and BMD can be described by the FPP, ICBMs and BMD correspond to an evolution in deterrence thinking, rather than a quantum leap. MIRVs can also be described by the FPP, suggesting some additional robustness of the FPP with regards to future technology changes. This suggests existing deterrence and compellence concepts can be used to analyze the strategic implications of future NAHWS. One significant limitation of this conclusion is considered in *Hypothesis Number 2*.

	Punishment	Denial	Risk
Compellence	-Incentivize first strikes -Counter-value strikes	-Desperation strikes -Decapitating first strike -Arms race	-Controlled escalation -Enable tactical nuclear strikes
Deterrence	-Deter nuclear weapon use -Discourage first strike	-Prevent first strikes -Hardening -Large arsenals -Nuclear triad	N/A

Table 1. *Summary of how various arguments about ICBMs and BMD map to the FPP.*

Hypothesis Number 2

The FPP has been used to categorize arguments about deterrence and compellence with regards to ICBMs and BMD. To understand whether these arguments are potentially germane to future weapons systems, *Hypothesis Number 2* considers how rapidly ICBMs evolved over time with respect to speed, range, and accuracy. Classifying these systems as quantum leaps in capability suggests the FPP is robust with respect to these technical characteristics. If these systems are best described as an evolution in technology, the applicability of the FPP may be better understood by directly examining projected NAHWS characteristics rather than by analogy to existing systems. On one hand, this suggests caution may be advised when predicting the roles of future of NAHWS for deterrence or compellence if hypersonic systems have drastically different characteristics than ICBMs. On the other hand, if future systems are evolutions in capability relative to current ICBMs, then perhaps their roles for deterrence and compellence may well be similar to those of ICBMs.

The Atlas ICBM used a one and a half stage liquid fueled engine. All engines ignited inside the launch tube and the booster engines were jettisoned in midflight. This was technically simpler than designing a true second stage rocket where each stage ignited sequentially.[136] The follow-on Titan series used a two-stage, liquid-fueled rocket and incorporated improved materials and manufacturing techniques to increase fuel capacity and range.[137] The Titan I used radio-controlled guidance, while the Titan II relied on more accurate inertial guidance technology.[138]

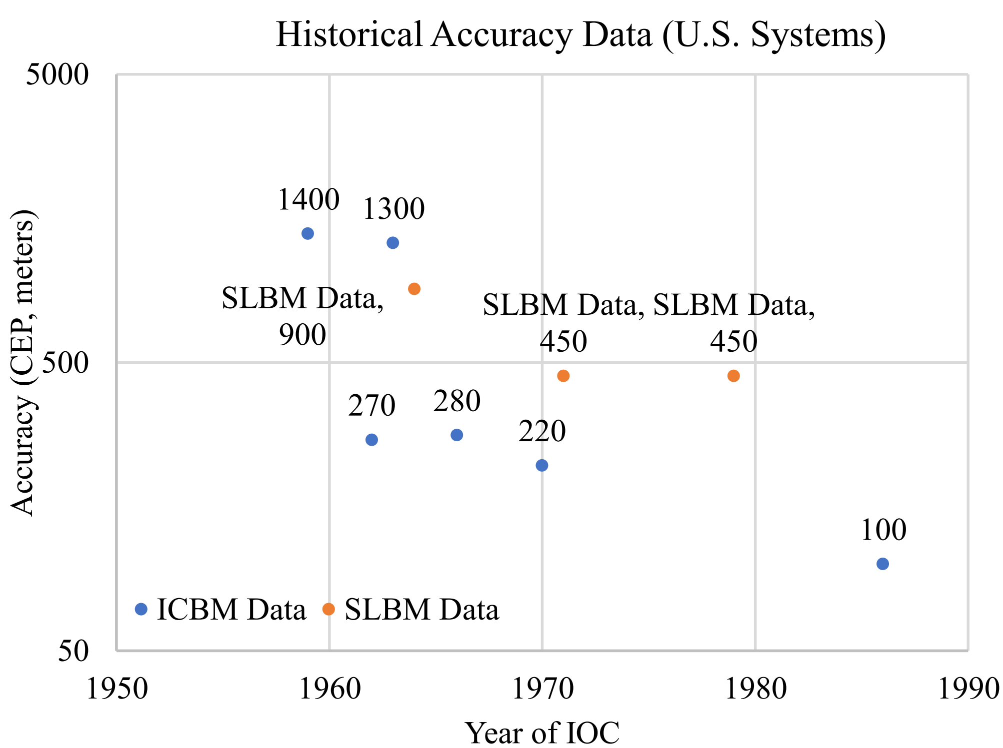

Figure 1. *The accuracy of United States ICBMs and SLBMs as a function of the year they obtained an Initial Operational Capability (IOC).*[139]

As shown in *Figure 1,* ICBMs generally increased their accuracy through each technology upgrade. The Minuteman I was approximately five times more accurate than the Atlas over a three-year period, a change small enough to qualify as an evolution in technological capability. Comparing the Atlas to the Peacekeeper shows accuracy increased by a factor of 14 over a 27-year period, again qualifying as an evolution in technological capability.[140] A similar analysis shows Russian and Chinese ICBMs and SLBMs were characterized by evolutionary changes in terms of speed, range, and accuracy.[141]

The Minuteman series upgraded the ICBM fleet with solid rocket boosters as a means to enable rapid launch capabilities.[142] The Minuteman III improved relative to the Minuteman II by increasing the number of warheads in order to offset potential BMD systems.[143] The Peacekeeper missile system advanced to three solid-fueled booster stages. Furthermore, instead of leaving its silo using rockets, the Peacekeeper ejected from the silo using gases, allowing the rocket engines to ignite in mid-air. This technique, known as cold launching enabled the missile to fit more tightly into the silo, increasing the size and ultimately the payload of the missile system.[144] While the technology incorporated into ICBMs improved over time, these changes largely focused on increasing missile survivability. For example, increasing the number of warheads made missiles less vulnerable to BMD systems, while rapid launch technically enabled launch-on warning postures as a means to increase ICBM survivability.

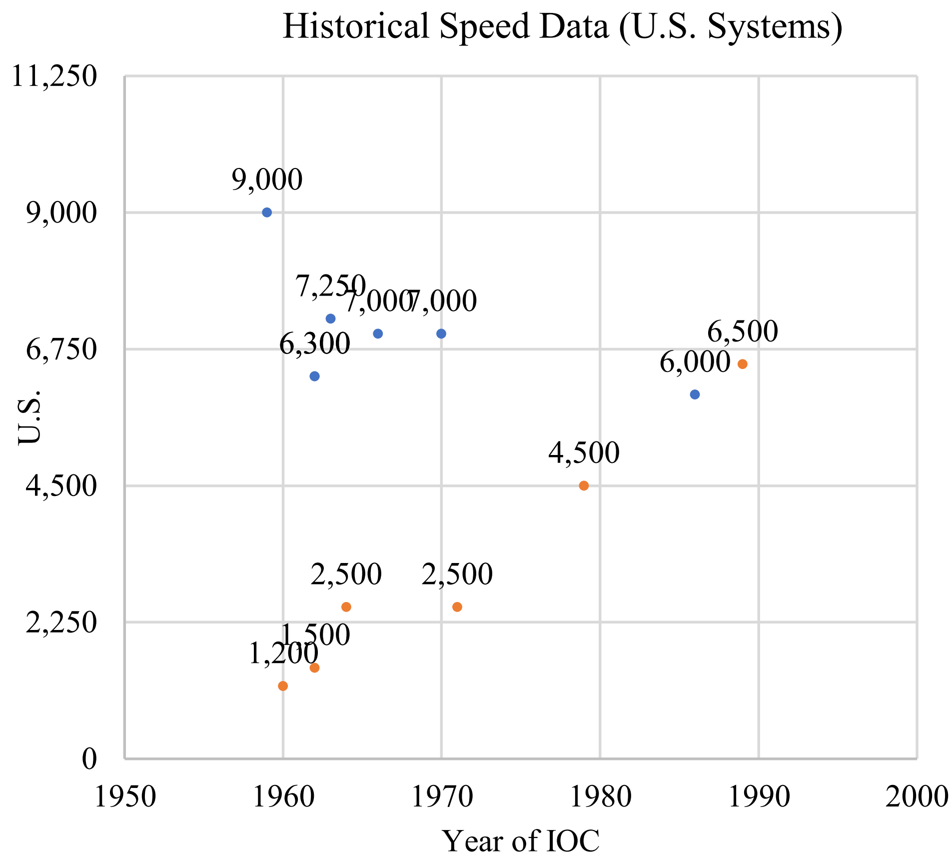

Figure 2. *The range of ICBMs (blue dots) and SLBMs (orange dots) as a function of the year they obtained an IOC.*[145]

As seen in *Figure 2*, the range of ICBMs did not substantially increase over time. Since they could already cross continents, additional range improvements may have been gratuitous. On the other hand, technology improved the relatively short ranges of SLBMs to eventually equal ICBM ranges. This arguably increased the operational attack range of submarines, making them harder to find in a vast ocean and thereby increasing their survivability. Overall, changes in ICBM technological capability are better described as an evolution in technical capability than as a quantum leap.

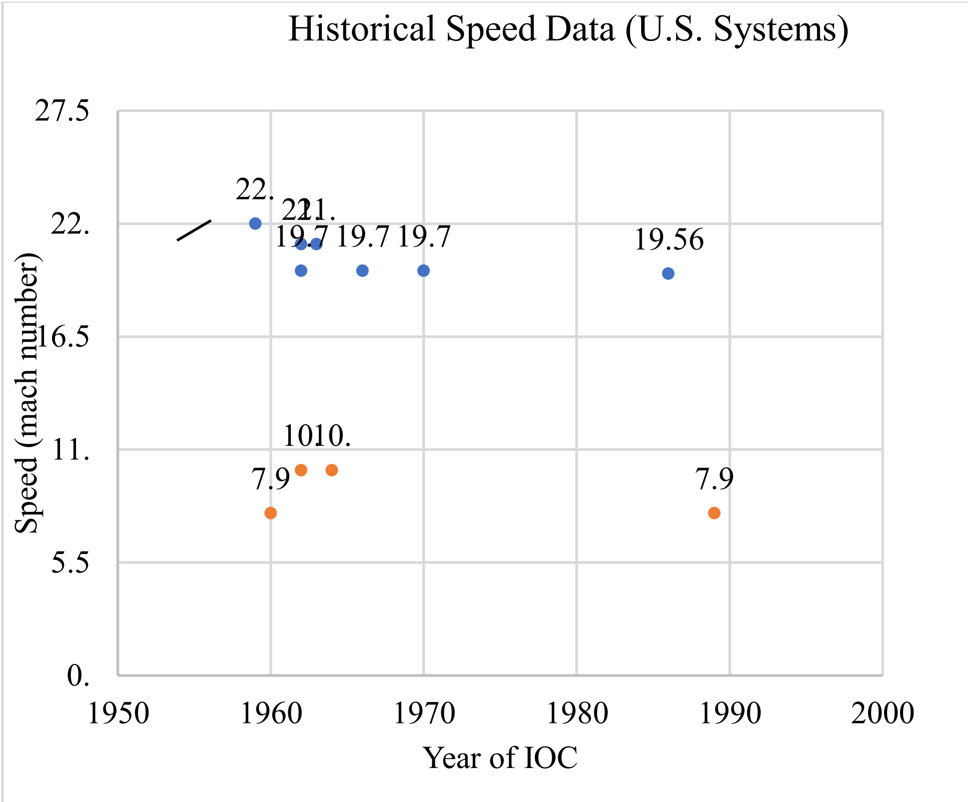

Figure 3. *The speed of missiles as a function of the year they obtained an IOC.*[146] *ICBMs shown in blue and SLBMs in orange.*

Finally, *Figure 3* shows the speed of ICBMs and SLBMs did not increase as ICBM and SLBM systems were upgraded. Technology developments focused more on quickly exiting the silo and less on quickly reaching the target. This contrasts with conventional hypersonic strike weapons focused on rapidly attacking fleeting targets. Nuclear weapons could also be used in a limited nuclear war against large military formations, but massed ground forces or fixed military bases are much less fleeting than high-value targets traveling by truck. Survivability against BMD is a potential issue, but historically ICBM designs and tactics dealt with this problem through other means, rather than by increasing missiles speed beyond Mach 20. Increasing speeds may not matter for prompt nuclear strikes since SLBMs and other shorter-ranged ballistic nuclear weapons can already strike targets very rapidly.[147]

In terms of range, speed, and accuracy, ICBMs are best described by evolutions in technical capability rather than by quantum leaps in technology. Since these three characteristics evolved slowly, the FPP may only accurately describe evolutionary improvements in weapons technology. If NAHWS combine ICBM and BMD characteristic synergistically rather than additively, perhaps NAHWS will present significantly different opportunities and threats with regards to deterrence and compellence. On the other hand, if NAHWS are an evolution relative to current ICBMs, perhaps the nuclear deterrence/compellence implications will be no more impactful than previous ICBM upgrades.

Furthermore, the FPP has been used to describe a wide range of weapons including MIRV systems along with a number of different forms of fielded and notional BMD systems capable of defending against various classes of missiles.[148] Additionally, while not specifically examined in this paper, nuclear-armed bombers outfitted with gravity bombs or cruise missiles can be described with historic deterrence and compellence arguments. Perhaps the FPP is robust enough to describe future NAHWS as well.

Hypothesis Number 3

This section considers the utility of NAHWS relative to the utility of ICBMs for deterrence and compellence. BMD systems would likely prove inadequate for large salvos of missiles consistent with punishment strategies or with the salvos envisioned by ragged defense, suggesting ICBMs and NAHWS are functionally equivalent for deterrence and compellence by punishment. Similar arguments suggest ICBMs and NAHWS are equally suitable for massive deterrence by denial operations attempting to eliminate nuclear forces possessed by Russia or China. Therefore, ICBMs and NAWHs are equally suitable for deterrence by denial, deterrence by punishment, and compellence by punishment.

The suitability of ICBMs relative to NAHWS for compellence by denial or compellence by risk depends in large part on the effectiveness of adversary BMD systems. Among other factors, this depends to a considerable degree on when during the conflict the weapons are launched. As the war progresses, the functionality of BMD systems may evolve. They may be damaged by attack, degrading BMD effectiveness. It is also possible new BMD systems could be fielded, either to mitigate battle damage or to improve capability beyond what was active at the beginning of the conflict. War could conceivably motivate rapid technological or operational improvements in BMD technology and systems. The exact details of a future dynamic scenario are impossible to analyze, but the losing side may have considerably less effective missile defense than the winning side. If during the conventional phase of a limited war, an adversary's BMD systems are effectively neutralized, NAHWS provide little advantage for compellence relative to ICBMs.[149]

Deploying NAHWS while simultaneously deploying conventional hypersonic weapons raises concerns about warhead and destination ambiguity. However, American bombers have been capable of carrying both nuclear and conventional weapons since 1956.[150] The current U.S. aircraft fleet includes dual-capable aircraft.[151] The United States believes Russia also has a "large, diverse, and modern" set of dual-capable weapon systems.[152] Likewise, bombers and cruise missiles can change course, meaning they have the potential for destination ambiguity, although their smaller speeds make this less of a concern. It is therefore unlikely NAHWS will pose any greater risk of warhead or destination ambiguity than other legs of the nuclear triad.

Conclusion

Anticipating the utility of future NAHWS for deterrence and compellence is difficult, as predicting the future always is. One way to forecast the implications of these advancements is to consider how current systems such as ICBMs and BMD are described in terms of deterrence and compellence. Historical upgrades of ICBM capability in terms of range, speed, and accuracy are best described as an evolution in capability rather than a quantum leap. This suggests future NAHWS are most likely to be described by existing deterrence and compellence models if hypersonic technology changes slowly relative to existing ICBM systems.

There are several limitations of this study. Complete operational data on hypersonic systems and their capabilities (range, speed, and accuracy) are not widely available because these systems are still under development and potentially classified. ICBM data was used as one proxy for evaluating the future rate of technological change, so future studies might focus on changes in technological capability for other similar classes of weapons including cruise missiles and short- or intermediate-range ballistic missiles. Evaluating the rate of change in the more complex arena of BMD technology is another complicated, but potentially fruitful research direction.

Another significant limitation of this study lies in its attempt to predict the impact of future systems by assuming upcoming systems to be a superposition of older systems. It is quite possible that the new systems will be a synergistic combination of older capabilities, possibly different enough to qualify as a quantum leap in technological capability. If so, the FPP might inadequately describe it. It is also possible that NAWHS will have enough new capabilities that they will be best described as something other than as ICBMs with built-in missile capabilities. In that case, NAHWS may still be described in terms of the FPP, but in a context different from than ICBMs or BMD.

However, policy makers do not have the luxury of choosing a development path based on a perfect, full-fledged knowledge of future fielded systems and therefore must find some other means of analysis. Based on this analysis of the existing data, replacing ICBMs with a NAHWS provides only limited potential advantages in terms of either deterrence or compellence. When conducting or threatening deterrence by punishment, deterrence by denial, and compellence by punishment, BMD will likely be overwhelmed by the sheer number of weapons involved, suggesting NAHWS provide no significant advantage. For compellence by risk and compellence by denial, the analysis is more uncertain because it depends on the potential BMD capabilities of an adversary. BMD capabilities at the beginning of a war will be less relevant than BMD capabilities later in the war. It may turn out the losing side in a limited war derives the most benefit from NAHWS.

Notes

1. Bernard Brodie, "The Absolute Weapon: Power and World Order," in *War in the Atomic Age*, ed. Bernard Brodie, (New Haven, Conn.: Yale University Institute of International Studies, 1946), p. 25. Brodie cites a post-World War II survey study suggesting it would have taken 730 bombers to do the same damage done by the one nuclear bomb dropped on Hiroshima.

2. For an overview of nuclear weapon and delivery technology developments during the Cold War see Dietrich Schroeer, *Science Technology and the Nuclear Arms Race* (New York, N.Y.: John Wiley & Sons, 1984).

3. Brodie, "The Absolute Weapon: Power and World Order," p. 76.

4. Lawrence Freedman, *Deterrence*, (Malden, Mass.: Polity Press, 2004), p. 16.

5. Lawrence Freedman, *The Evolution of Nuclear Strategy* (Palgarve MacMillan: New York, N.Y., 2003), pps. 51, 74.

6. See for example Colin S. Gray, *The Future of Land-Based Missile Forces* (London, U.K.: International Institute for Strategic Studies), p. 1. See also Chapter 7 of Albert Legault and George Lindsey, *The Dynamics of the Nuclear Balance* (Ithaca, N.Y.: Cornell University Press, 1976).

7. Freedman, *The Evolution of Nuclear Strategy*, p. 21.

8. James Acton, *Silver Bullet? Asking the Right Questions about Conventional Prompt Global Strike* (Washington, D.C.: Carnegie Endowment for Peace, 2013), p. 5.

9. Ibid., p. 6.

10. Ibid., pps. xiii, 9-11.

11. Ibid., pps. 73-78.

12. Acton, *Silver Bullet? Asking the Right Questions about Conventional Prompt Global Strike* discusses the possibility of using hypersonic missiles to develop conventional weapons. See also Eleni Ekmektsioglou, "Hypersonic Weapons & Escalation Control in East Asia," *Strategic Studies Quarterly*, vol. 9, no. 2 (Fall 2015), p. 43; Joshua H. Pollack, "Boost-Glide Weapons and US-China Strategic Stability," *Non-Proliferation Review*, vol. 22, no. 2 (February 2016), p. 155; and Richard H. Speier, George Nacouzi, Carrie L. Lee, and Richard M. Moore*, Hypersonic Missiles Nonproliferation: Hindering the Spread of a New Class of Weapons,* (Santa Monica, Calif.: RAND Corporation, 2017), p. iii.

13. Speier et al., *Hypersonic Missile Proliferation: Hindering the Spread of a New Class of Weapons,* p. xii. Also see Kyle Mizokami, "China Conducts New Hypersonic Weapon Test: Beijing Hopes Hypersonic Weapons Will Help It Leap to Parity with The U.S. Military," *Popular Mechanics*, Aug. 7, 2018, www.popularmechanics.com/military/weapons/a22665761/china-conducts-new-hypersonic-weapon-test.

14. Anton Troianovski and Paul Sonne, "Russia is to Add New Hypersonic Nuclear-Capable Glider to its Arsenal," *Washington Post*, Dec. 26, 2018. Also, U.S. Government Accountability Office, *National Security, Long-Range Emerging Threats Facing the United States as Identified by Federal Agencies*, GAO-19-204SP (Washington, D.C., 2018), pps. 4, 9, accessed Feb. 23, 2019, www.gao.gov/assets/700/695981.pdf.

15. Office of the Secretary of Defense, *Nuclear Posture Review* (Washington, D.C.: Department of Defense, 2018), p. X.

16. Office of the Assistant Secretary of Defense for Nuclear Matters, *Nuclear Matters Handbook 2016* (Washington, D.C.: Department of Defense, 2016), pps. 26, 30.

17. Office of the Secretary of Defense, *Nuclear Posture Review*, pps. 44-5; Office of the Assistant Secretary of Defense for Nuclear Matters, *Nuclear Matters Handbook 2016*, p. 26.

18. Office of the Secretary of Defense, *Nuclear Posture Review*, p. 45

19. Matthew Kroenig, "The Case for the U.S. ICBM Force," *Strategic Studies Quarterly,* vol. 12, no. 3 Fall 2018, pps. 63-4.

20. Office of the Secretary of Defense, *Nuclear Posture Review*, p. 45.

21. Keir A. Lieber and Darryl G. Press, "The New Era of Counter-Force: Technological Change and the Future of Nuclear Deterrence," *International Security,* vol. 41, no. 4 (Spring 2017), p. 30, https://doi.org/10.1162/ISEC_a_00273.

22. Ibid., p. 32.

23. Schroeer, *Science Technology and the Nuclear Arms Race*, p. 107.

24. Ibid., pps. 110-12.

25. Ibid., p. 115.

26. Ibid., pps. 114-5.

27. Ibid., p. 109.

28. Thomas G. Mahnken, *The American Way of War* (New York, N.Y.: Columbia University Press, 2008), p. 30 and Schroeer, *Science Technology and the Nuclear Arms Race*, p. 107.

29. Schroeer, *Science Technology and the Nuclear Arms Race,* p. 151. See also Ronald Huisken, *The Origin of the Strategic Cruise Missile,* (New York, N.Y.: Praeger Publishers, 1981), p. 16.

30. Schroeer, *Science Technology and the Nuclear Arms Race*, p. 151.

31. Ibid., p. 144.

32. Ibid., p. 202.

33. Lieber and Press, "The New Era of Counter-Force: Technological Change and the Future of Nuclear Deterrence," p. 24.

34. Ibid., p. 24.

35. Schroeer, *Science Technology and the Nuclear Arms Race*, p. 201.

36. Lieber and Press, "The New Era of Counter-Force: Technological Change and the Future of Nuclear Deterrence," p. 16.

37. Ibid., p. 10.

38. Ibid.

39. Ronald L. Tammen describes a series of missile technology advancements designed to increase survivability, including speed, stealth, decoys, chaff, alternate trajectories, radiation hardening, and electronic countermeasures. For details, see Tammen, *MIRV and the Arms Race, An Interpretation of Strategy,* (New York, N.Y.: Praeger Publishers, 1973), pps. 85-6.

40. Huisken, *The Origin of the Strategic Cruise Missile*, p. 15. See also Brodie, "The Absolute Weapon: Power and World Order," p. 29.

41. Bernard Brodie and Fawn M. Brodie, *From Crossbow to H-bomb* (Bloomington, Ind.: Indiana University Press, 1973), pps. 230-31.

42. Huisken, *The Origin of the Strategic Cruise Missile*, pps. 16-7.

43. Ibid., p. 29.

44. Lawrence Freedman, "The Small Nuclear Powers," in *Ballistic Missile Defense*, ed., Ashton B. Carter (Washington, D.C.: The Brookings Institution, 1984), p. 253.

45. Schroeer, *Science Technology and the Nuclear Arms Race*, p. 236.

46. Alexsey Aratov and Vladimir Dvorkin, "The Impact of MIRVs and Counterforce Targeting on the US-Soviet Strategic Relationship," in *The Lure and Pitfalls of MIRVs*, ed. Wheeler Krepon, Travis Wheeler and Shane Mason, (Stimson Center, 2016), pps. 70-1. See also Jeffrey G. Lewis, "China's Belated Embrace of MIRVs" in *The Lure and Pitfalls of MIRVs*, ed. Krepon, et al., pps. 95, 100, 110. While Ronald L. Tammen suggests MIRVs are a response to BMD technology, he suggests there were other motivations as well. See Tammen, *MIRV and the Arms Race, An Interpretation of Strategy*, pps. 104, 107, 113-4, 137.

47. For a review of BMD technology, see National Research Council, *Making Sense of Ballistic Missile Defense: An Assessment of Concepts and Systems for US Boost Phase Missile Defense in Comparison with Other Alternatives*, (Washington, D.C.: National Research Council, 2012), www.nap.edu/read/13189. See also Ashton B. Carter, "BMD Applications: Performance & Limitations," in *Ballistic Missile Defense*, ed. Ashton B. Carter, (Washington, D.C.: The Brookings Institution, 1984), pps. 124-9.

48. Gen. Martin E. Dempsey, *Joint Integrated Air and ABM: Vision 2020*, p. 3, states the only way to defeat large salvos of ICBMs is through preemptive strikes, implying missile defense is inadequate to deal with a large salvo of missiles. The *2019 Missile Defense Review* states the United States is "protected against a limited attack" by ICBMs. See Office of the Secretary of Defense, *2019 Missile Defense Review*, (Washington, D.C.: Office of the Secretary of Defense, 2019), p. XII. President George Bush viewed BMD as necessary to protect the United States against rogue nations and terrorists, emphasizing the utility of BMD against small salvos of ICBMs. See for example, Terence Neilan, "Bush Pulls Out of ABM Treaty; Putin Calls Move a Mistake," *The New York Times*, Dec. 13, 2001. Lawrence Freedman makes a similar observation, i.e. Freedman, *Deterrence*, p. 37.

49. Acton, *Silver Bullet? Asking the Right Questions about Conventional Prompt Global Strike*, p. 5; Ekmektsioglou, "Hypersonic Weapons & Escalation Control in East Asia," p. 43; Pollack, "Boost-Glide Weapons and US-China Strategic Stability," p. 155, https://doi.org/10.1080/10736700.2015.1119422. However, this definition technically includes ICBMs and SLBMs as hypersonic weapons because they travel faster than Mach 5. See for example, see Office of the Secretary of Defense, *Nuclear Posture Review*, p. 45.

50. Acton, *Silver Bullet? Asking the Right Questions about Conventional Prompt Global Strike*, pps. 5-7.

51. Considering all Mach 5 and above systems to be hypersonic makes a NAWHS replacement for the ICBM redundantly meaningless. Instead, this paper envisions NAWHS as fast, intercontinental ranged weapons that do not completely follow a ballistic flight trajectory.

52. Acton, *Silver Bullet? Asking the Right Questions about Conventional Prompt Global Strike,* p. 121.

53. DARPA's Glide Breaker program is one example. See Joseph Trevithick, "DARPA Starts Work on Glide-Breaker Hypersonic Weapons Defense Project," *TheDrive.com*, Sept. 6 2018, www.thedrive.com/the-war-zone/23398/darpa-starts-work-on-glide-breaker-hypersonic-weapons-defense-project. Space-based defenses are another possibility, see Bill Gertz, "Pentagon Plans to Deploy Space Based Missiles," *Free Beacon*, Sept. 5, 2018, https://freebeacon.com/national-security/pentagon-plans-deploy-space-based-missiles. *Missile Defense Review* states the United States is actively working to counter the threat of hypersonic weapons. See Office of the Secretary of Defense, *2019 Missile Defense Review*, pps. XX, 58, 59, 79, 80.

54. Acton, *Silver Bullet? Asking the Right Questions about Conventional Prompt Global Strike*, p. 75.

55. Ibid., pps. 76-7.

56. Ibid., pps. 76-7.

57. Ibid., p. 63.

58. Ibid., p. 68.

59. Ibid., p. 64.

60. Ibid., pps. 64, 71-3.

61. Glenn H. Snyder, *Deterrence and Defense: Toward a Theory of National Security* (Princeton, N.J.: Princeton University Press, 1961), p. 15. See also Brodie, "The Absolute Weapon: Power and World Order," p. 76.

62. Thomas C. Schelling, *Arms and Influence* (New Haven, Conn.: Yale University Press, 2008), pps. 22-3.

63. Schelling, *Arms and Influence,* p. 17.

64. Ibid., p. 216.

65. Office of the Secretary of Defense, *Nuclear Posture Review*, p. 22.

66. Schelling, *Arms and Influence*, p. 27.

67. Freedman, *Deterrence*, p. 37.

68. Robert Anthony Pape, *Bombing to Win: Air Power and Coercion in War* (Ithaca, N.Y.: Cornell University Press, 1996), p. 36.

69. Pape, *Bombing to Win: Air Power and Coercion in War*, pps. 13-15, 49.

70. Ibid., p. 36.

71. Ibid., pps. 12-13, 16, 50.

72. Pape considers these to be types of coercion, but the way Pape defines coercion is similar to the way that Schelling defines compellence. To avoid confusion, compellence will be used in this paper.

73. Pape, *Bombing to Win: Air Power and Coercion in War*, pps. 6-15.

74. In addition to the older, aforementioned arguments of Brodie, Snyder and Pape, a recent restatement of this argument was made by John Mueller, see Mueller, "Nuclear Weapons Don't Matter but Nuclear Hysteria Does," *Foreign Affairs, vol.* 97, no. 6, (November/December, 2018), p. 10.

75. See Herman Kahn, *On Thermonuclear War*, (Piscataway, N.J.: Transaction Publishers, 2007), p. 16 for a definition of counterforce. Others who believe nuclear weapons are useful for warfighting include Russian and American military planners who incorporate low-yield nuclear weapons into their military arsenals. See Office of the Secretary of Defense, *Nuclear Posture Review*, pps. 22, 53-4. Lawrence Freedman argued that tactical nuclear weapons could be useful for warfighting by attacking logistical or other forces deep inside enemy territory as described in Freedman, *The Evolution of Nuclear Strategy,* pps. 106-8.

76. Pape, *Bombing to Win: Air Power and Coercion in War*, pps. 28, 50, 55, 57. Lawrence Freedman suggests that many early strategists were "notably" vague about the "actual mechanisms" for collapsing civilian morale. See Freedman, *The Evolution of Nuclear Strategy*, p. 9.

77. Pape, *Bombing to Win: Air Power and Coercion in War*, pps. 18-19, 57.

78. Ibid., p. 68.

79. Ibid., p. 67. Pape was also doubtful collapse was a credible potential outcome.

80. Patrick M. Morgan, *Deterrence: A Conceptual Analysis*, (Beverly Hills, Calif.: Sage Publications, 1983), p. 32.

81. Merriam-Webster Dictionary, *s.v*. "defense," www.merriam-webster.com/dictionary/defense.

82. Snyder, *Deterrence and Defense: Toward a Theory of National Security*, p. 5.

83. Ibid., p. 14.

84. Schelling, *Arms and Influence*, p. 130.

85. Ibid., p. 135.

86. Lawrence Freedman agreed with Schelling and argued that existing attitudes and relationships may be altered. See Freedman, *Deterrence*, p. 113.

87. Schelling, *Arms and Influence*, p. 111.

88. Ibid., p. 113.

89. Scott D. Sagan, and Kenneth N. Waltz, *The Spread of Nuclear Weapons: An Enduring Debate* (New York, N.Y.: W.W. Norton & Company, 2013), p. 28.

90. Schelling, *Arms and Influence*, p. 230. See also Morgan, *Deterrence: A Conceptual Analysis*, p. 29. Focusing on the role of deterrence in limited war means the discussion will center around immediate deterrence focusing on deterring a specific threat at a specific time, whereas general deterrence deters a broad range a of aggression. For a discussion of immediate vs general deterrence, see Morgan, *Deterrence: A Conceptual Analysis*, pps. 28-30, 40-43, or Freedman, *Deterrence*, 40-42.

91. Schelling, *Arms and Influence,* pps. 151-2, 162-166.

92. Ibid., pps. 173, 190-208.

93. Ibid., pps. 166-8.

94. Ibid., pps. 24-27.

95. Speier et al., *Hypersonic Missile Proliferation: Hindering the Spread of a New Class of Weapons,* pps. 10-11; Ekmektsioglou, "Hypersonic Weapons & Escalation Control in East Asia*," p.* 59; Acton, *Silver Bullet? Asking the Right Questions about Conventional Prompt Global Strike*, pps. 65-71

96. Acton, *Silver Bullet? Asking the Right Questions about Conventional Prompt Global Strike*, pps. 73-8; Speier et al., *Hypersonic Missile Proliferation: Hindering the Spread of a New Class of Weapons,* p. 10.

97. Acton, *Silver Bullet? Asking the Right Questions about Conventional Prompt Global Strike*, pps. 78-81; Ekmektsioglou, "Hypersonic Weapons & Escalation Control in East Asia*,"* p. 43.

98. Acton, *Silver Bullet? Asking the Right Questions about Conventional Prompt Global Strike*, p. 38.

99. Schroeer, *Science Technology and the Nuclear Arms Race*, pps. 108-113.

100. While this is somewhat arbitrarily tied to our base 10 number system, this delineation has the advantage of being neither too small to see an empirical change nor too large to be an exaggeration. As order of magnitude arguments often form the basis for broad analysis in physics, a factor of 10 is justified for measuring the argument. As a robustness check, I will also measure order of magnitude using a factor of three and a factor of 50 to see how the arguments hold.

101. Ted Nicholas and Rita Rossi, *U.S. Missile Data Book, Volume 1, 36th edition* (Huntington Beach, Calif.: Data Research Associates, 2012), tables 1-1, 1-2, 3-1 and 3-2.

102. Schroeer, *Science Technology and the Nuclear Arms Race.*

103. See for example National Research Council, *Making Sense of Ballistic Missile Defense: An assessment of Concepts and Systems for US Boost Phase Missile Defense in Comparison with Other Alternatives.* This discusses the utility ABM systems, which are highly dependent on the scenario.

104. The generic term nuclear weapon is used, but the arguments specifically apply to nuclear delivery systems potentially held at risk by BMD, most notably ICBMs. The arguments probably apply to SLBMs as well. There is some limited discussion about how ICBMs may be used in conjunction with tactical nuclear weapons.

105. Morgan, *Deterrence: A Conceptual Analysis*, pps. 28-40, see also Freedman, *Deterrence*, pps. 40-42.

106. Acton, *Silver Bullet? Asking the Right Questions about Conventional Prompt Global Strike*, pps. 111-118.

107. Ibid.

108. John K. Warden, "Limited Nuclear War: The 21st Century Challenge for the United States," *Livermore Papers on Global Security*, No. 4, p. 48.

109. George Schneiter, "The ABM Treaty Today," in *Ballistic Missile Defense*, ed., Ashton B Carter (Washington, D.C.: The Brookings Institution, 1984), pps. 248-9.

110. Ibid., pps. 248-9.

111. See Herman Kahn, *On Thermonuclear War* for definitions and examples of these deterrence types. They can be found sprinkled throughout the book. Specifically, see pages 12-13, 126, 174, 305, 447, 377, 505,527, 545, 547.

112. Kroenig, "The Case for the US ICBM Force," pps. 56-7.

113. Ryan Snyder, "The Future of the ICBM Force: Should the Least Valuable Leg of the Triad be Replaced?" Arms Control Association Policy White Paper, (Washington, D.C.: Arms Control Association, March 2018). See also Glenn H. Snyder, *Deterrence and Defense: Toward a Theory of National Security*, pps. 4-5.

114. Brendan Rittenhouse Green and Austin Long, "The Geopolitical Origins of US Hard-Target Kill Counterforce Capabilities and MIRVs," in in *The Lure and Pitfalls of MIRVs*, ed. Krepon, et al., p. 22, www.stimson.org/sites/default/files/file-attachments/Lure_and_Pitfalls_of_MIRVs.pdf.

115. Freedman, *Deterrence,* pps. 85-89.

116. Roman Kolkowicz, "Intellectuals and the Nuclear Deterrence System," in *The Logic of Nuclear Terror*, ed. Roman Kolkowicz (Winchester, Mass.: Allen & Unwin, Inc., 1987), p. 34.

117. Ashton B. Carter, "BMD Applications: Performance & Limitations," p. 122. See also Legault and Lindsey, *The Dynamics of the Nuclear Balance,* p. 189.

118. Freedman, *Deterrence*, p. 37.

119. Ashton B. Carter, "Introduction to the BMD Question," in *Ballistic Missile Defense*, ed. Ashton B Carter, (Washington, D.C.: The Brookings Institution, 1984), pps. 7-8.

120. Pape, *Bombing to Win: Air Power and Coercion in War,* pps. 20, 25, 28, 55, 57. Freedman comments many strategists were vague about the mechanisms capable of destroying civilian morale. See Freedman, *The Evolution of Nuclear Strategy*, p. 8. Both Pape and Freedman seemed pessimistic about the utility of this mechanism for obtaining concessions.

121. Henry Kissinger, *Nuclear Weapons and Foreign Policy* (New York, N.Y.: Harper & Brothers, 1957), p. 98.

122. Sagan, and Waltz, *The Spread of Nuclear Weapons: An Enduring Debate*, p. 105.

123. Ashton B. Carter, "Introduction to the BMD Question," p. 22. Along similar lines, Kahn argued that increased defenses or evacuations could be used to give first strike an increased advantage. See Herman Kahn, *On Thermonuclear War*, p. 14.

124. Schneiter, "The ABM Treaty Today," pps. 248-9.

125. Pape, *Bombing to Win: Air Power and Coercion in War*, p. 56.

126. Schelling, *Arms and Influence*, 230; Olga Oliker, "Moscow's Nuclear Enigma: What is Russia's Arsenal Really For," *Foreign Affairs*, (November/December 2018), p. 54. Another Russian defense expert argued in any major conflict, the United States would start to use its conventional advantage to eliminate Russia's nuclear capability, leaving Russia little choice but to respond with nuclear weapons. See James T. Quinlivan and Olga Oliker, *Nuclear Deterrence in Europe: Russian Approaches to a New Environment and Implications for the United States* (Arlington, Va.: RAND Corporation, 2011), p. 24.

127. Warden, "Limited Nuclear War: The 21st Century Challenge for the United States," p. 8; Lawrence Freedman, "On the Tiger's Back: The Development of the Concept of Escalation," in *The Logic of Nuclear Terror*, ed. Roman Kolkowicz (Winchester, Mass.: Allen & Unwin, Inc., 1987), p. 116.

128. Herman Kahn, *On Thermonuclear War*, pps. 126, 174, 282, 377, 545, 547.

129. Leon Sloss, "The Strategist's Perspective," in *Ballistic Missile Defense*, ed. Ashton Carter (Washington, D.C.: The Brookings Institution), pps. 38-9. Sloss also argues that ABM is destabilizing because it increases the number of weapons needed for deterrence. See also Ashton B. Carter, "Introduction to the BMD Question," p. 23. For a discussion of MIRVs, see Michael Krepon and Travis Wheeler, "Introduction," in *The Lure and Pitfalls of MIRVs*, ed. Krepon, et al., p. 15, www.stimson.org/sites/default/files/file-attachments/Lure_and_Pitfalls_of_MIRVs.pdf; Alexsey Aratov and Vladimir Dvorkin, "The Impact of MIRVs and Counterforce Targeting on the US-Soviet Strategic Relationship," in *The Lure and Pitfalls of MIRVs*, ed. Krepon, et al., pps. 88-99, www.stimson.org/sites/default/files/file-attachments/Lure_and_Pitfalls_of_MIRVs.pdf.

130. Colin Gray, 1987, "Nuclear Deterrence and Technological Change: Retrospect and Prospect," in *The Logic of Nuclear Terror*, ed. Roman Kolkowicz (Winchester, Mass.: Allen & Unwin, Inc., 1987), pps. 155-185.

131. Kissinger, *Nuclear Weapons and Foreign Policy*, p. 119.

132. For example, President Dwight Eisenhower leveraged the threat of nuclear weapons in negotiations over the end of the Korean War. See Freedman, *The Evolution of Nuclear Strategy*, p. 80. See also Rosemary J. Foot, "Coercion and Ending the Korean War," *International Security*, vol. 13, no. 3 Winter 1988-89, pps. 92-112.

133. Schelling, *Arms and Influence,* pps. 105-6.

134. Warden, "Limited Nuclear War: The 21st Century Challenge for the United States," p. 31.

135. Some arguments about ICBMs and BMD are not described by the FPP, including arguments about cost or morality. Since these arguments describe neither deterrence or compellence, that limitation is deemed immaterial.

136. Eric Burgess, *Long-Range Ballistic Missiles*, (New York, N.Y.: The Macmillan Company, 1961), p. 46; *Jane's Weapons: Strategic*, p. 55, (Surrey, U.K.: IHS Global Limited, July 2011), p. 660.

137. Ibid., pps. 48, 50, 51, 105-9.

138. *Jane's Weapons: Strategic.* pps. 55, 662.

139. Nicholas and Rossi, *U.S. Missile Data Book, Volume 1, 36th edition*, Table 3-2, pages 3-6 through 3-9 and Table 1-2, page 1-6. Also see Schroeer, *Science Technology and the Nuclear Arms Race*, p. 176. For accuracy of the Atlas missile, see "SM-65 Atlas," GlobalSecurity.org, accessed Feb. 24, 2019, www.globalsecurity.org/wmd/systems/sm-65.htm, which specifies CEP. Note the *Air Power and Space Journal* cites the accuracy of 10 miles, but provides no indication of whether this indicates circular probable error. See APSJ staff, "Atlas the Godfather of ICBMs and Space Launch Vehicles," *Air and Space Power Journal*, vol. 17 no. 1, p. 68.

140. These conclusions hold even using the more restrictive factor of three definition when considered on a per year basis.

141. For example, the Russian SS-11 (mod 2) had a range of 13,000 kilometers in 1973. In 1988, the SS-18 (mod 6) had a range of 16,000 km. Several other variants including the SS-17, SS-19, SS-24, SS-25 and several variants the SS-18 had shorter ranges than the SS-11 (mod 2). The range difference between SLBMs increased from 7,800 km in 1973 (SS-N-8) to 8,300 km in 1985 (SS-N-23). Again, several intermediate variants had less range than the SS-N-8. The accuracy of Russian ICBMs decreased from 1,675 meters circle of equal probability (CEP) in 1973 (SS-13 mod 2) to 200 meters in 1987 (SS-24). See Thomas B. Cochran, William M. Arkin, Robert S. Norris, and Jeffrey Sands, *Nuclear Weapons Data Book*, (New York, N.Y.: Harper & Row Publishers, 1989), 4:111, 4:114. See also Schroeer, *Science Technology and the Nuclear Arms Race*, pps. 56, 63-5, 68-72.

142. Burgess, *Long-Range Ballistic Missiles,* p. 183.

143. Schroeer, *Science Technology and the Nuclear Arms Race*, p. 153.

144. Schroeer, *Science Technology and the Nuclear Arms Race*, pps. 155-6; see also *Jane's Weapons: Strategic*, pps. 658-59.

145. Nicholas and Rossi, *U.S. Missile Data Book, Volume 1, 36th edition*, Table 3-2, pages 3-6 through 3-9 and Table 1-2, page 1-6. Also see Schroeer, *Science Technology and the Nuclear Arms Race*, p. 176 and U.S. Library of Congress, Congressional Research Service, *Strategic Forces: MX ICBM,* by Jonathan Medallia, p. 1.

146. See Nicholas and Rossi, *U.S. Missile Data Book, Volume 1, 36th edition*, Table 3-2, pages 3-6 through 3-9 and Table 1-2, page 1-6. See also Schroeer, *Science Technology and the Nuclear Arms Race*, p. 176; However, Nicholas and Rossi report the speed of the Peacekeeper to be Mach 4, which is inconsistent with information provided by other sources. So instead, speed of Mach 20 is reported. A speed of Mach 20 is consistent with speed values reported in other sources, such as National Museum of the U.S. Air Force, www.nationalmuseum.af.mil/Visit/Museum-Exhibits/Fact-Sheets/Display/Article/197974 /boeing-lgm-118a-peacekeeper. The database "Military Periscope" also reports the speed is approximately Mach 20: www-militaryperiscope-com.aufric.idm.oclc.org/weapons/nuclearbiologicalchemical/nuclear-strategic/lgm-118-

peacekeeper-icbm. Both estimates convert to Mach number by assuming the speed of sound is approximately 767 miles per hour.

147. An SLBM travels roughly the same speed as an ICBM, but can be fired from much closer, suggesting they can be significantly more prompt than ICBMs.

148. National Research Council, *Making Sense of Ballistic Missile Defense: An Assessment of Concepts and Systems for US Boost Phase Missile Defense in Comparison with Other Alternatives*, p. 74 lists a variety of fielded and planned systems along with a number of different sensor systems, all capable of defense at different stages of missile flight.

149. Lawrence Freedman made a similar argument that the side with superior conventional forces will be less likely to escalate with nuclear weapons than the side with inferior conventional forces. See Freedman, *The Evolution of Nuclear Strategy*, pps. 110-11.

159. Office of the Historian, Department of State, "51. Telegram from the North Atlantic Council Ministerial Meeting of the Department of State," *Foreign Relations of the United States, 1955-1957, Western European Security and Integration, Volume IV*, (Dec. 14, 1956), www.history.state.gov/historicaldocuments/frus1955-57v04.

151. Office of the Secretary of Defense, *Nuclear Posture Review*, pps. II, X, 16, 49.

152. Office of the Secretary of Defense, *Nuclear Posture Review,* p. 49.

Terry

CHAPTER 3

U.S. Hypersonic Weapons and China Deterrence Effects

Colonel John D. Varilek, U.S. Air Force

> "*War itself became an exercise in managing the future, and the most successful commanders were not those most experienced in the ways of the past but, on the contrary, those who realized that the past would not be repeated. In addition to becoming sustained, technological progress also became deliberate and therefore, up to a point, predictable*."[1]
>
> – Martin Van Creveld

Throughout history the domains and nature of warfare have been in a state of evolution as new and different technologies become available and are adopted for military application. From the building of large fortifications, sieging of castles, to battles of the high seas, followed by air to air battles of manned aircraft and eventually the capability to overfly all obstacles to deliver a nuclear payload, technology has changed and sometimes revolutionized the art of war. However, many technologically important military tools did not originate from a government requirement or set of parameters. Breach-loading rifles, rifled-steel cannons, submarines, airplanes, helicopters and electronic computers among others, were all build out of the ingenuity and thoughtfulness of civilian entrepreneurs or scientists.[2] Militaries have adapted these technologies in efforts to provide an advantage should the need arise to enforce the political will on another state or to provide a credible military power in order to deter an unwanted action.

Studies conducted by the RAND Corporation and others have highlighted the rise of hypersonic technology in various countries (especially the United States, Russia and China) and have documented suggested courses of action associated with the development and implementation of these new weapon systems.[3] However, the effects on Indo-Pacific strategy and policy implications of this emerging weapons technology require further scrutiny through the lens of deterrence theory. As each major region of the world presents different challenges, the examination of the relationship and linkages between the United States and China will allow for recommendations of national policy for hypersonic weapon technology employment that maximizes deterrence and minimizes destabilizing effects between the United States and China.

The 2017 National Security Strategy (NSS)[4] provides the foundation and two important themes for the formulation of this paper. These themes nested within the first three pillars[5] of the NSS are: recapturing the global lead in technology and innovation[6] along with maintaining a credible nuclear deterrent.[7] While nuclear deterrence is essential to combating threats from nuclear-armed nations, the NSS goes on to state that the United States must "extend deterrence across all of these (land, air, maritime, space, and cyberspace) domains and must address all possible strategic attacks."[8] This NSS verbiage provides the justification for political and military leaders to examine other weapon systems and policies in order to gauge their deterrent effects and thus provide for a more complete and all-encompassing national deterrence policy.

The U.S. Nuclear Posture Review (NPR)[9] also provides for additional direction in framing U.S. policy and possible courses of action in the Indo-Pacific region. The NPR promotes a nuclear arsenal to accomplish the following tasks: 1. Deter nuclear and non-nuclear attack; 2. assure allies and partners; 3. achieve U.S. objectives should deterrence fail; and 4. maintain a capacity to hedge against an uncertain future. The NPR provides further strategic focusing by calling out China's modernization of nuclear forces and new nuclear capacities. For example, China's increase in ballistic missile submarines (SSBNs) and nuclear-capable bombers without regard to stating intentions has drawn cause for concern in U.S. assessments. Similar to the NPR, the 2018 U.S. National Defense Strategy (NDS)[10] and the NSS name China as a strategic competitor and revisionist power. The United States sees China as a rising hegemony power that is exploiting the world order established after World War II while undercutting the principles upon which it was founded.

Turning to hypersonics, the United States and China (along with Russia) are aggressively pursuing hypersonic technology and are considered the farthest along on the global stage of weapons development of this technology.[11] Countries such as India, France, Japan, Australia and the European Union are also in various stages of pursing hypersonic technology while countries such as Brazil, Canada, Iran, Israel, Pakistan, Singapore, South Korea and Taiwan are showing signs of academic interests in hypersonic applications.[12]

The congressional budget has allocated funds to all three major U.S. service components (Air Force, Navy and Army) for pursuing hypersonic technology. Consequently, each service is working to find the right balance between cost of purchase, technology maturation and military effectiveness within their spheres of influence and within a joint perspective. Therefore, redundancy and policy implications must be examined to assure the United States is effectively distributing technology throughout the service branches and that these assets provide the desired political and/or military effect amongst the various platforms.

Several military and political agencies have expressed interest in various aspects of hypersonic technology and are pondering the consequences of pursing this technology. Therefore, to provide real-world application and purpose for this work, requests from HAF/A10 2018, HAF/A5 2017 and AFRLs 2017 will interlace into this project. In general, these requests share a common thread of seeking to understand how the development of new technologies affect the deterrence status quo. In order to address these requests, this project specifically focuses on the Unites States' deterrence relationship with China and asks, under what conditions does the development of hypersonic weapons influence the United States-China deterrence posture?

Background

The literature used to provide data to this research will fall into five broad categories: hypersonic basics, deterrence theory foundational data, defense policy, nuclear weapon policy, and hypersonic application data. The study conducted to answer the preceding research question and following hypothesis will develop through the lens of deterrence and deterrence theory. Although much scholarly work has been synthesized over the last 60 years regarding the maturation of deterrence theory, what deterrence is, where deterrence should apply, if deterrence works, etc., consensus of theory applicability and success is still very much in debate. However, both political and military leaders alike continue to promote the benefits of deterrence theory and emphasize its importance in the overall U.S. strategy.

Though definitions of deterrence theory vary, this paper will use the following RAND definition: "*Deterrence is the practice of discouraging or restraining someone in world politics, usually a nation-state – from taking unwanted actions, such as an armed attack. It involves an effort to stop or prevent an action.*[13]

Research Design

With that definition of deterrence in mind, the methodology for this paper follows that the design will be a comparative case study of American and Chinese actions to deterrence effecting technologies in the timeframe of 1945 to the present and how the technology advance of one nation does or does not affect the policy of the other. To provide a basis of research, this project will first examine the past technological development of nuclear weapons in the United States and then provide Chinese reactions to these technologies in the form of diplomatic speeches, military counteractions, and changes to internal policy after implementation. Additionally, a similar look at American-Chinese hypersonic weapon development will be examined in hopes of correlating relevant action/reaction markers in order to form a basis for future policy making analysis and hypothesis testing.

China has not provided transparency of its nuclear programs and policy decisions to the degree the United States and Russia have. Therefore, it becomes difficult to decisively ascertain the true nature of China's intentions, but through analysis of linkages between known United States technologies and accessible Chinese policies, speeches and weapons decisions, the author hopes to provide a baseline rationale between U.S. weapons policy and its perceived effect on Chinese deterrence. By examining accessible Chinese artifacts related to policy and military development to counter U.S. nuclear policy, it is hoped to correlate a policy recommendation that would be within the current status quo of U.S. deterrence theory.

Hypothesis

The primary hypothesis to be tested is one that presumes hypersonic weapons will have a negligible effect on Indo-Pacific deterrence under certain conditions. This hypothesis would support the belief that hypersonic weapons are a natural evolution of technology and thus status quo theory of United States-China relations should be expected. The counter argument to refute this hypothesis follows generally that hypersonic weapons will destabilize the United States-China relationship due to the inherent disconnect between reality and policy. This contrary belief would support hypersonic weapons as a technology bigger than the sum of its parts and would support a destabilizing theory of United States-China relations.

To state it plainly, the hypothesis listed below will work to provide evidence of the proposed theory that:

Emerging technology of hypersonic weapons will not significantly affect the deterrent stability of the United States-China relations if these countries restrict the hypersonic delivery vehicles to platforms that are vulnerable to a degree of attack themselves.

U.S. Background

In order to "*compete, deter and win,*" the U.S. National Defense Strategy provides objects to sustain military advantage in key global regions as well as deter adversaries, defend allies and ensure common domains are accessible in key regions.[14] In essence, until U.S. adversaries adhere to established norms and are able to walk the "*path of transparency and non-aggression,"* the United States will seek to *"remain the preeminent military power of the world*."[15] As part of the ability to remain the preeminent power, the United States will invest in modernizing the nuclear triad as well as other technologies that will ensure its ability to counter aggression and keep domains of air, land ,sea, space and cyberspace free and open. Hypersonic weapons may provide the next technological tool in the military toolkit of the United States to accomplish such a feat.

Technically, hypersonic weapons have been employed by the United States since the first flight of the Atlas intercontinental ballistic missile (ICBM) in 1957. The reentry vehicles for these and subsequent ICBMs reach hypersonic speeds and have served as the basis of study for other technical programs. Even as World War II was drawing to a close, leaders such as Generals Hap Arnold and Curtis Lemay realized the potential of innovative technology weapon systems that could travel at speeds of greater than Mach 5. Lemay was a supporter of the manned hypersonic space vehicle Boeing X-20 Dyna-Soar (Dynamic Soarer)[16] program and advocated to bring this technology and other spaced domain assets into fruition for the United States Air Force. The Dyna-Soar craft was meant to be a manned reusable space plane system that would provide the ultimate high ground to the U.S. Air Force in a variety of military fields.

However, as is often the case with unproven technology, Dyna-Soar was canceled in 1963 by then Secretary of Defense Robert McNamara because of being a too "narrowly defined program."[17] While many applications were subjects of debate for the Dyna-Soar program such as intelligence, surveillance and reconnaissance (ISR), fighter, bomber, as well as civilian applications, etc. researched information suggests that the Dyna-Soar program was always intended as an Air Force weapons program. However, budget issues for the unproven technologies (both hypersonic and competing systems) as well as the politics regarding space weaponization ultimately led to program cancelation. Bottom line, the system was canceled due to unrealized military benefits in conjunction with ill-defined deterrence policy capabilities and competing relatively affordable alternatives.

Thus, the allure of evolutionary technology such as satellite reconnaissance systems and intercontinental ballistic missiles gained greater funding rather than revolutionary technology such as a boost-glide hypersonic weapon or manned hypersonic craft. However, with the initial limitations of intercontinental ballistic missile (ICBM) technology, the threat of Soviet ICBMs, the push from Department of Defense and the equally unproven concept of satellite technology, hypersonic weapon system research continued to survive off and on throughout the 20th century.

The primary interest in hypersonic technology today for the United States and other countries focuses on two different types of weapons. The first weapon type is that of the boost-glide vehicle. These hypersonic systems generally use rocket engines to boost a weapon to an altitude below that of a ballistic missile trajectory (nominally 50 to 100 kilometers above the Earth surface).[18] The weapon is released from the booster and glides at hypersonic speeds to its intended targets. The second type of hypersonic weapon under current research is that of hypersonic cruise missile. This weapon system is powered throughout flight by either rockets or an engine system (such as a scramjet) at altitudes necessary to maintain an air breathing engine (likely 20 to 30 kilometers above the Earth surface).[19]

The main advantage to these types of hypersonic weapon systems over conventional cruise missiles and ICBM systems is that of a combination of speed, maneuverability and variable launch location. Generally, conventional cruise missiles have maneuverability and variable launch location abilities, but not speed. ICBMs have speed, but lack similar maneuverability and launch from fixed locations. Having the ability to lessen an enemy's detection range and reaction time while providing ambiguity to the actual target gives the operator of the weapon system a distinct advantage. Hypersonic weapons promise to realize this dream and should hold new target sets[20] at risk, such as those behind previously secure anti-access/area denial (A2AD) defenses, hard and deeply buried targets or those with overflight restrictions of a neighboring country. Additionally, current missile defenses are incapable or extremely limited in countering these new systems.[21]

Though pursuit of hypersonic cruise missiles with scram jet technology is ongoing, boost-glide vehicles are the technology that is maturing more readily and will be first ready for implementation in both the United States and People's Republic of China (PRC) militaries. The Department of Defense (DOD) has multiple service branches researching hypersonic technology and its possible applications. The Air Force appears the farthest along with at least two concepts reportedly getting close to operational status. However, Defense Advanced Research Projects Agency (DARPA), the U.S. Navy and the U.S. Army are also working on hypersonic technologies that include both air-breathing and boost-glide technologies.

Chinese Background

As previously mentioned, one of the key competitive rivals in hypersonic technology is China. In the late 20th century, China developed a Soviet conventional warfare style with positional defense and maneuver offensive meant for total war and conflict. This doctrine emphasized human factors, mass and protracted war over military hardware, formal command and control and quick, decisive battles. However, after China's loss in the Sino-Vietnam conflict in 1979, open calls for reform and doctrinal updates were expressed. Beginning in the mid-1980s the People's Liberation Army (PLA) has adopted a more agile structure that produces results in quick high-speed engagement over greater regional distances. The 1991 Gulf War appears to have influenced Chinese doctrine and solidified emphasis on local or limited wars in a rapid manner that culminate quickly with well-defined objectives. Additionally, since the 1990s China has been devoting greater resources to building its informational gathering and exploitation capabilities.

China also maintains an official policy of strategic defense by claiming to pursue a passive national defense modernizing program for its armed forces in order to safeguard its society. Additionally, China wishes to "promote unification, guard against and resist aggression; and to defend national sovereignty, territorial integrity, and maritime interests."[22] While critics to China's defense posture point to issues with the terms of "unification" and "territorial integrity," China counters that the military expansion is merely a response to more aggressive postures and rhetoric coming from both the United States and Japan. For example, China uses the Japanese *2004 White Paper on Defense and the New National Defense Program Outline* and U.S. ballistic missile defense programs along with maritime exercises to justify and its actions and regional territory claims.

Ka Po Ng[23] (an associate professor at Aichi Bunkyo University in Japan) argues in his 2005 book that Chinese doctrine is dependent on technology, but military concepts must roll in the technology into working plans in order to have the desired effects. Additionally, Ng purports contrary to Thomas Mahnken[24] strategy myths,[25] that China generally follows an international relations realists' point of view. If these concepts are true within a reasonable margin of error, anticipation of Chinese reaction to U.S. policy and weapons may be within grasp of debate. In almost every piece of current hypersonic capabilities literature the U.S. military and scientific officials advertise Chinese work on hypersonic weapons to be farther along than U.S. efforts. Accordingly, the Chinese tout a hypersonic propulsion test facility in Beijing[26] that can generate wind tunnel velocities of up to Mach 5.6, which they employ in their hypersonic research. In August 2018, the Chinese hypersonic glide system named Starry Sky 2 reportedly flew for 10 minutes at speeds of up to Mach 6 with successful rocket glide vehicle separation and follow-on hypersonic glider flight.[27] Like in the United States, the Chinese continue to research and build components and systems necessary for hypersonic cruise missiles technologies as well.[28] In summary the Chinese have watched the start-stop measures of the U.S. hypersonic programs and have mimicked investment in these technologies over an unknown number of years. Exactly when the Chinese initiated hypersonic programs is unknown, but the first successful tests of the Chinese concepts in 2014 have provided a catalyst for more focused U.S. research and development in the hypersonic field.

Deterrence

Deterrence is the practice of discouraging or restraining someone in world politics, usually a nation-state — from taking unwanted actions, such as an armed attack. It involves an effort to stop or prevent an action.[29]

– Michael Maazar (RAND Corporation)

With the advent of possibly game-changing technologies arriving in rival nations, it begs the question of if these technologies can, will or should undermined our deterrent postures towards one another? To examine this thought we will first briefly look at deterrence theory and how it may apply to the given problem. The father of deterrence theory Thomas Schelling viewed deterrence through the lens of game theory. He presumed that when nuclear weapons were involved the employment of the rational actor model was necessary due to the extreme consequences of the situation.[30] The rational actor model assumed that a state would use a risk reward calculus to: clarify goals, order goals by importance, lists alternatives, investigate consequences and then chooses best alternatives. His model also presumes an actor has sufficient time to formulate the correct course of action and the adversary is also rational. Additionally, Schelling theorized that a nation's defenses are unbalancing, therefore both sides should be vulnerable to attack for deterrence to work properly. By having a number of nuclear weapons and presenting a credible threat to an adversary's population, it was believed that deterrence by punishment will be effective to keep an adversary from attacking.

Conversely, Herman Kahn (also based his theory on rational actor model) advocated for deterrence not only by punishment, but also by denial. He disagreed with the single-minded *"mutual-homicide"* theory of deterrence. Kahn believed that there were three types of deterrence (passive, active, and tit-for-tat) and stated that countries needed to be able to fight and win in a nuclear war.[31] He argued for phased programs of deterrence, planning for different levels of nuclear war, planning for fighting after nuclear war and making plans to recover from the effects of a nuclear war. He was not only an advocate for being ready to fight a nuclear war but believed a state should be able to credibly threaten to initiate one in order to provide a more credible deterrence posture.

In summary to deterrence theory, Schelling believed that preparing for war would lead to a self-realizing prophecy of the war happening. However, establishing brinksmanship and trip-wire actions correctly, he theorized a country could deter an adversary from attacking by providing off-ramps to its actions.[32] Kahn believed that the best way to deter an enemy from attacking was to prepare for all phases of war and instead of providing an off-ramp, he proposed using an escalation ladder to either escalate or deescalate the tensions between adversaries.[33]

Comparing the United States and China

U.S. Nuclear Policy

Both the United States and China developed nuclear technologies, but history shows us that the countries applied them in very different ways. The United States was the first to develop nuclear weapons and after entering an arms race with the Union of Soviet Socialist Republics eventually adopted the policy of mutual assured destruction (until the end of the Cold War). The United States produced large stockpiles and built a trinity of delivery vehicles to provide a credible nuclear deterrent for its primary adversary. The 2018 NPR gives a comprehensive view of current U.S. nuclear policy: "*U.S. nuclear capabilities make essential contributions to the deterrence of nuclear and non-nuclear aggression. The deterrence effects they provide are unique and essential to preventing adversary nuclear attacks, which is the highest priority of the United States*." The NPR contains information regarding how the United States will continue to modernize and rely on its nuclear triad of bombers, SSBNs and ICBMs[34] until such time as nuclear weapons are no longer necessary to maintain a peaceful world order. The NPR also portrays the United States leading the world in an effort to eliminate the need for nuclear weapons, but will not arbitrarily relinquish its nuclear arsenal until other countries demonstrate the same policies and adherence to world peace.

Finally, the NPR specifically calls out flexible response options as part of the U.S. nuclear policy. This policy recognizes that there is not a "one size fits all"[35] policy of deterrence. The flexible response policy is linked to the deterrent value of assuring an adversary cannot hope to lower the nuclear threshold to the point of a favorable response (i.e. no nuclear retaliation). U.S. policy and deterrence strategies have been the subject of much debate and scholarly writing over the last 60 years and much literature is readily available for digestion. What is not readily available is the PRC's defense strategy with accompanying nuclear policies. However, some material does exist and is presented in the following sections.

China's Nuclear Policy

With the aid of Russian expertise and technology, the Chinese developed a minimum deterrence posture or assured retaliation capability.[36] Even after China built the economic and scientific capital required to amass a nuclear arsenal to rival both the United States and Russia it has not yet committed to proceed in that strategic direction as emphasized in the following excerpt from China's 2006 defense strategy:

"[China's] fundamental goal is to deter other countries from using or threatening to use nuclear weapons against China. China remained firmly committed to the policy of no first use of nuclear weapons at any time and under any circumstances… China upholds the principles of counterattack in self-defense and limited development of nuclear weapons, and aims at building a lean and effective nuclear force capable of meeting national security needs … China's nuclear force is under the direct command of the Central Military Commission. China exercises great restraint in developing its nuclear forces. It has never entered into and will never enter into a nuclear arms race with any other country."[37]

The retired Chinese Major General Zhenqiang Pan[38] describes China's nuclear policy in terms of the traditional Chinese 21st century rhetoric and in the context of its stated no-first-use. Pan quotes China's 1964 statement of "not be the first to use nuclear weapons at any time or under any circumstances"[39] as the underlying principle of their nuclear policy as well as the notions of founding leadership, ancient Chinese wisdom and China's active defense strategy. While the western views of China's limited or minimal defense paint China in a certain light, Pan retorts that these views do not fully capture the defensive only nature of the Chinese nuclear arsenal.

Chinese Major General (retired) Yunzhu Yao also articulates that China's nuclear policy has been consistent since the beginning of the PRC's nuclear era. The policies put forward include "no first use" coincide with the goals of complete prohibition of nuclear weapons, limited development of retaliatory capability, rejection of extended deterrence and protection of non-nuclear weapon states from nuclear weapons. These policies feed the themes of strategic, retaliatory, central, general, defensive and minimum deterrence posture.[40]

Contrary to the official U.S. position on its nuclear arsenal, China describes the United States and Russia as having an offensive nuclear arsenal and how this strategy led to the arms race, heavy spending deep mistrust and unnecessary competition during the Cold War. Conversely, China fashioned its nuclear policies in order not to be drawn into battle on an adversary's terms. China instead chose the asymmetric strategy of active defense by adopting a no-first-use policy in order to not only follow its defensive strategy holistically, but to also dissuade superpowers from seeing China as a nuclear threat.

China reports its ability to adjust policies to fit current times and adversary updates. In his arms control and proliferation writings, Gu Guaoliang[41] articulates that China has revised its arms control and nonproliferation policies to better align with international norms.[42] In terms of future nuclear policy updates, China acknowledges that there have been challenges internally to the no-first-use policy. However, Chinese rebuttal of western criticism to their lack of transparency of their nuclear arsenal and policies stems from their claim of the completely defensive nature of their doctrine. Chinese officials argue that preservation of a small defensive force requires technical secrecy of the arsenal when the adversary promotes an offensive posture.[43] Therefore, China's nuclear arsenal appears aligned with its reported defenses posture.

U.S. Hypersonic Weapons

Turning once again to the primary topic of hypersonics, literature suggests that officially in the DOD, only generalized mission requirements are available for hypersonic weapons. However, James Acton in a Carnegie Endowment study summarized some general mission sets broadly as "the ability to hold distant, time-critical, highly defended, fleeting targets at risk."[44] Information from additional think tanks and opinion papers have provided a number of possible mission sets for this new system in the United States, which could encompass a number of different operations depending on the actual size, speed and payload of the final systems under development.

Recently published works suggest hypersonic weapons are candidates for a new category of Air Force Global Strike options within the framework of Conventional Prompt Global Strike (CPGS).[45] Under CPGS, the mission sets include: counter-nuclear as well as missions such as counter terrorism, conventional attack, countering anti-satellite (ASAT) missiles, and negating adversary A2/AD systems. Correspondingly, other missions such as ISR, air-to-air engagement, hard and deeply buried target mitigation (HDBT), and anti-shipping missions are also areas of interest. Without a clear mission requirement, the DOD has been given the order to proceed with hypersonic weapon development. In pursuing this goal, the DOD is actively working hypersonic weapon development in multiple domains and services.

Air Platforms

The Air Force appears to be working on a tried and true relatively low-cost option for hypersonic delivery platform integration. The revered B-52 looks to be the platform of choice[46] for the initial implementation of both the Advanced Rapid Response Weapon (ARRW) or "Arrow" and the Hypersonic Conventional Strike Weapon (HCSW) or "Hacksaw. Both of these systems are contracts awarded to Lockheed Martin with estimated initial operational capability dates in 2021 and 2022 respectively.[47] These systems appear to be boost-glide weapons that if carried on the B-52 outfitted with additional upgrades including reengining, data link network and software modifications are hoped to provide the DOD a range of options for hypersonic weapon employment.

The advantages to mounting hypersonic weapons on a bomber are numerous. From a technical point of view, a bomber has the capacity and range to carry a relatively large number of weapons to prosecute a number of afore mentioned DOD mission sets. The technical disadvantages for mounting these weapons on bombers is that bombers may still require support assets such as tankers for long loiter times or possible mission changes. Weather and aircraft maintenance are also considerations, but no more than other hypersonic weapon launch platforms. Finally, depending on the intended mission set, aircraft data link systems coupled with C2 will be of paramount importance for inflight target changes and/or mission aborts.

Sea Platforms

The U.S. Navy (USN) is focusing on acquiring offensive hypersonic weapons by 2025 for a self-reported specific Line of Effort.[48] The Navy conducted a land-based test in October 2017 on a boost-glide concept[49] and is working toward designs for implementation on sea-based hypersonic systems.[50] While the official DOD and USN policies and concepts of operation are still being discussed and considered, the current hypersonic effort focuses on designing a weapon system suitable for use on submarine platforms as it is presumed that the less restrictive environment of surface vessel employment will be easier to adapt should policy dictate the non-use of hypersonic weapons on submarines.

The USN sees the hypersonic capability broadly as a direct contributor to the CPGS doctrine of being able to hit any target on the planet within an hour.[51] This assumes USN vessels within a given area of operations (AOR) carrying hypersonic weapons integrated into a robust C2 structure. Like air platforms, the naval data link/C2 structure would have to allow for either complete missile route plans to be sent to the launch platforms or minimum targeting data in order for onboard planning systems to rapidly process the target set and load it into the weapon system for launch. It should be noted that in general, the more maneuverable a weapon system is expected to be during its mission, the more planning that must go in to making the system function as advertised.

Land Platforms

The U.S. Army is also currently engaged in a Long-Range Hypersonic weapon program, that builds off the U.S. Navy's hypersonic booster in order to create a road-mobile hypersonic system.[52] This system is reported to be a boost-glide system that is able to open up lanes in an A2/AD environment. In additional to the challenges that the other services are working on, another particular technical challenge is the operating environment and transport issues that a road-mobile system would encounter. The system may have to endure temperature extremes of below freezing or hot tropical environments in addition to weapon stability concerns during transport and repositioning in austere terrain.

Chinese Hypersonic Weapons

Limited literature on Chinese nuclear modernization and hypersonic technology suggests that PRC hypersonic weapons could be a successor to Chinese strategic bombers and or ICBMs.[53] Nevertheless, both PRC bombers and ICBMs continue to be modernized and upgraded. Additional information suggests that the weapon systems could employ in ways that mimic U.S. efforts. However, if considering integration of hypersonic weapons with current modernization of Chinese land, sea and air platforms along with a generalized defensive posture, a likely first course of action would be to extend contested regional dominance farther from mainland China. While offensive-minded analysts of the PRC intent would point to observation of Chinese naval vessels on beyond regional patrol, the PRC would still require a significant number of hypersonic weapons (and other systems) to pose a true offensive threat to the U.S. mainland or its nuclear deterrent capabilities.

U.S. Deterrence Options

From a deterrence prospective both Schelling and Kahn should agree that an offensive weapon on a bomber would provide deterrence benefits for the United States. A bomber aircraft can be visibly, moved and postured to send a clear aggressive deterrence signal to an adversary. Additionally, if diplomacy prevails, bombers recall and unloading sends equally clear signals of intent. However, Schelling would most likely be concerned that hypersonic weapons themselves coupled with reliable intelligence would be destabilizing. The weapon system has the capacity of rendering a country's nuclear arsenal vulnerable in a first-strike scenario as well as reducing the time an enemy has to ascertain adversary intent. Kahn, however, would contend that this weapon system is exactly what is required to fight and win a war either conventional or nuclear.

Between underwater and surface vessels, the latter would most likely be the preferred Schelling platform since it doesn't move relatively fast, is easier to track for a technically savvy adversary and is thus presumably vulnerable to attack itself. Additionally, moving surface vessels, like bombers, sends a clear signal to a potential adversary that the United States is in the area and is ready to fight for a certain policy or action. Submarine-launched weapon systems would most likely be looked as a destabilizing for deterrence in a Schelling model for an adversary that cannot or has limited ability to find, fix, track, and engage submarine vessels. Kahn and realism advocates would see the benefits of a stealthy delivery platform that could fire weapons of lethal intent over great distances and arrive at their targets in just minutes. To an adversary such as China with a defensive realist[54] point of view, this weapon system would potentially destabilize its overall defense regional hegemony posture and cause the nation to invest more heavily in anti-submarine weapon systems, underwater reconnaissance and increasingly hardened retaliatory weapon systems. This buildup could then cause the United States to become concerned that China is working to expand its naval power of an offensive realist[55] view thus causing an unintentional additional naval arms race in other arenas.

Land-based systems from a deterrence perspective would be basically like aiming a long-range gun at an adversary from its backyard. Additionally, given the mobile concept of the system, an adversary's targeting problem would also pose a challenge. However, to hold targets at risk on say the east coast of China, realistically these mobile systems would reside on island chains or peninsulas in the Indo-Pacific Area or Responsibility (AOR) limiting mobility to a certain extent, but movement should still be possible. However, their initial employment and/or continued employment could have a destabilizing effect on Schelling's deterrence theory unless used as a counter to Chinese forward deployments of similar weapon systems. An alternative political option could be to have the systems developed and ready to deploy, but wait until tensions reach a prescribed level. Then deploying hypersonics provides a signal to China that the United States is committed to protection of the region and is willing to strike if needed in order to provide peace. Alternatively, a forward deployment of ground-based hypersonic weapons to the Indo-Pacific AOR may also be justified as a Kahn's tit-for-tat posture for continued militarization of the South China Sea islands by the PRC or a realist reaction to events of political concern.

Chinese Deterrence Options

The Chinese leadership, especially during the Mao Zedong era, felt that in order to not be bullied by nuclear nations China must also have nuclear weapons. The Chinese strategy of a few nuclear weapons aimed at large U.S. population centers is a credible deterrent given the other environmental factors of Chinese geography and society. Specific threats illustrated in Chinese literature regarding escalation concerns manifest primarily as perceived U.S. interference in Taiwan and the development of ballistic missile defense systems.

China worries about the U.S. ballistic missile defense (BMD) program and U.S. discussions of flexible lower yield nuclear options (as well as other perceived technical advantages) as threats to its defense strategy. For example, China fears a U.S. strike that damages its nuclear arsenal, which then allows BMD to negate the retaliatory nuclear capability and strategy. Also, if the United States would choose to employ lower yield nuclear weapons (or hypersonic weapons) on strategic military targets, the response of large warheads on American cities could appear to be an escalation factor that may be too extreme for China to execute. While some Chinese officials such as Major General (retired) Yao do not believe a conflict with Taiwan would logically escalate to nuclear war, they do believe that BMD systems and U.S. "freedom of navigation" missions are destabilizing in nature and threaten to cause great damage to the Sino-U.S. relationship.[56]

Additional Considerations

In August 2018, Undersecretary of Defense for Research and Engineering Michael Griffin[57] made a public proposal that the United States build a mega constellation of satellites in order to detect and track adversary hypersonic weapons. He also contends that while the United States has been investigating hypersonic technology for years, it wasn't until our adversaries started to weaponize these research concepts that the United States was compelled to respond in kind. However, not only are the Air Force, Army, and Navy proceeding with hypersonic weapon design, the Pentagon's Missile Defense Agency (MDA) is working on ways of countering hypersonic weapons. The MDA director has confirmed that the agency is collaborating with the various service hypersonic programs to produce ways of detecting[58] and defeating[59] hypersonic weapons.

Similarly, Chinese scientist Qian Qihu has recently boasted of an "Underground Steel Great Wall" capable of intercepting missiles that were previously too fast to intercept.[60] The obvious connotation is that the Chinese are working on a hypersonic defense system. The article discusses the philosophy of developing a shield with the spear. Whether or not it matters who is reacting to whom, both the United States and the PRC appear to be pursing similar technologies in both offense and defense hypersonic technology.

Recommendations

In keeping with Martin Van Crevald's edict of not "putting all your eggs in one basket" (i.e. relying on a single technology, weapon, or tactic) "it only makes the enemy's job easier,"[61] the United States is researching multiple avenues of hypersonic weapon offense and defensive capability. However, the policies of both the United States and China to employ these potentially deterrence disruptive technologies have yet to be fully realized and disseminated. Therefore, the following recommendations are included in order to attempt to mitigate a future arms race of hypersonic weapon technology, provide positive actions for deterrence theory to continue to work and build a basis of future trust between nations.

Provided that China is 1) pursuing a Mearsheimer defensive realisms view on world power competition, 2) China feels its current nuclear arsenal is protected and an effective deterrent to U.S. nuclear strikes, and 3) China does not have expansion policies outside its current AOR; then the following recommendations would make the best case for negligible hypersonic effects on deterrence.

Both countries should start bilateral negotiations regarding key hypersonic technology proliferation. By agreeing on what is deemed exportable it will thus negate future proliferation concerns or augments that run counter to more pressing international and security concerns. Additionally, the politically sensitive issue of mounting nuclear warheads on the weapon systems must be addressed.

Though ICBMs, SLBMs and cruise missiles can be fitted with nuclear warheads, the transparency of each countries program regarding nuclear weapons and hypersonic systems should be acknowledged and accepted by both countries in order to avoid an unnecessary arms race. Hypothetically, adding nuclear warheads on air-breathing hypersonic systems seems the most logically unprovocative choice if the two nations were to want to explore this route. For the United States, it means a more survivable bomber nuclear delivery system, which at the present disadvantages the PRC as they do not yet have the robust intercontinental bomber force. However, given the recent modernization and bomber build up in the PRC, it may be an area of consideration upon which both countries can agree.

Adding conventionally armed hypersonic weapons to air, land and sea surface delivery platforms should be agreed upon and signed into treaty between the United States and China. Given the arguably defensive policy of the current Chinese government, it is in the best interest of the United States to keep weapons development and policies in line with a deterrence strategy that best promotes the continuation of that policy. If the United States and the PRC can agree to limit hypersonic weapons technology from space platforms as well as underground and undersea platforms then each side will have the perceived vulnerabilities necessary for deterrence to continue to work.

Finally, a conceived framework of discussion between the United States and China that provides information constituting hostile action warranting the use of nuclear weapons by the attacked must be explored. Both the United States and the PRC fear that hypersonic weapons could be used either as a precursor to nuclear attack or to remove a country's nuclear capabilities and render the other a strategic eunuch. However, if a clear understanding of the "no first us policy" and targets of strategic importance (i.e. Nuclear Command and Control or early warning systems) are discussed, a possible miscalculation of future unintended escalation may be contained.

Conclusion

With the current steady build up and modernization of the Chinese military, the trend has been viewed by some U.S. analysts as China moving away from a strategy of minimum deterrence/assured retaliation and toward a more aggressive bid for regional hegemony. China remains committed to the notion that these improvements are necessary to improve capability to survive a first strike and assure a credible retaliation and its strategy of "dynamic minimum deterrence."[62] China counters that the U.S. pursuit of missile defense systems, its infringement on China's area of influence and conventional global strike capability are destabilizing and the reason for its investment in its own modernization.

U.S. hypersonic research and development supports the current NSS, NDS and NPR in that they provide tools for the U.S. military to balance out the assumed rise of PRC hegemony desires. These weapon systems, from an offensive realist point of view, will help maintain a U.S. Indo-Pacific hegemony with the goal of maintaining the currently established world order. Additionally, the United States may use these weapon systems to further deterrence postures in either the punishment or denial realms of deterrence theory depending on placement, platform and vulnerability of the launch platforms.

Consequently, Chinese hypersonic weapons seem to be another piece of the strategic puzzle meant to help bring it out of a "*century of humiliation*" and extend the defensive posture of the mainland in its quest to become the preeminent power in the Indo-pacific region. As such PRC hypersonic weapon pursuance can be rationalized as consistent with a defensive posture, current nuclear strategies and mimic like expansion of technology. Like the holding large cities at risk in PRC nuclear deterrence, hypersonic weapons are surmised to deter the United States in the Indo-pacific region by holding at risk U.S. Navy power projection and land-based strategic assets. By extending the PRC defensive umbrella, it continues to complicate U.S. response and reaction times to any crisis in the Indo-pacific region.

Hypersonic weapons can provide the next revolutionary technological tool in the United States military toolkit. With all three major service components pursuing the technology, the DOD must find the right balance between technology efficiency and military effectiveness within its spheres of influence while considering a realistic deterrent perspective. Given that both the United States and

China will successfully develop hypersonic technologies and weaponize the systems in its conventional arsenals this need not be a cause for alarm. If a thoughtful national deterrence strategy is considered while developing these new weapon systems, as the preceding work and summary in *Figure 1* below is hoped to portray, then the emerging technology of hypersonic weapons will not significantly affect the stability of United States-China relations.

	Effects on Deterrence	
Platforms	Schelling*	Kahn*
Air Launched	Status quo	Positive
Sea Surface	Positive	Status quo
Sea Subsurface	Negative	Positive
Land based **	Negative	Positive

*Authors interpretation of deterrence theorist's predictions
** Assumed deployed to AOR immediately upon acquisition

Figure 1. *Summary of U.S. hypersonic delivery Platform Effects on Deterrence in the Indo-Pacific region*

Notes

1. Martin Van Creveld, *Technology and War*, Free Press, 1991, p. 218.

2. Martin Van Creveld. *Technology and War*, Free Press, 1991, p. 220.

3. Richard H. Speier, George Nacouzi, Carrie L. Lee, and Richard M. Moore*, Hypersonic Missiles Nonproliferation: Hindering the Spread of a New Class of Weapons,* (Santa Monica, Calif.: RAND Corporation, 2017).

4. White House, *National Security Strategy of the United States of America*. (Washington, D.C.: U.S. Government Printing Office, December 2017).

5. The Pillars of the NSS: "Protect the American people, the homeland and the American way of life. Promote American prosperity. Preserve peace through strength. Advance American influence."

6. NSS, pp. 20: "Lead in research, technology, invention, and innovation: The United States will build on the ingenuity that has launched industries, created jobs, and improved the quality of life at home and abroad. To maintain our competitive advantage, the United States will prioritize emerging technologies critical to economic growth and security, such as data science, encryption, autonomous technologies, gene editing, new materials, nanotechnology, advanced computing technologies, and artificial intelligence. From self-driving cars to autonomous weapons, the field of artificial intelligence in particular is progressing rapidly."

7. NSS, pp. 30: "The United States must maintain the credible deterrence and assurance capabilities provided by our nuclear triad and by U.S. theater nuclear capabilities deployed abroad. Significant investment is needed to maintain a U.S. nuclear arsenal and infrastructure that is able to meet national security threats over the coming decades."

8. NSS, pp. 27-31.

9 Office of the Secretary of Defense, *Nuclear Posture Review* (Washington, D.C.: Department of Defense, 2018), www.defense.gov.

10. Department of Defense, *2018 National Defense Strategy of the United States of America,* (Washington, D.C.: Department of Defense, 2018).

11. Speier, et al, *Hypersonic Missiles Nonproliferation: Hindering the Spread of a New Class of Weapons*).

12. Ibid.

13. Michael. M. Maazar*, Understanding Deterrence,* (Santa Monica, Calif.: RAND Corporation, 2018).

14. Department of Defense, *2018 National Defense Strategy of the United States of America,* (Washington, D.C.: Department of Defense, 2018).

15. Department of Defense, *2018 National Defense Strategy of the United States of America,* (Washington, D.C.: Department of Defense, 2018).

16. Roy F. Houchin, *U.S. Hypersonic Research and Development,* (Routledge, 2006).

17. Ibid.

11. Speier, et al, *Hypersonic Missiles Nonproliferation: Hindering the Spread of a New Class of Weapons*.

19. Ibid.

20. Ibid.

21. Ibid.

22. Gu Guoliang, *Chinese Arms Control and Nonproliferation Policy*, Christopher P. Twomey*, Perspectives on Sino-American Strategic Nuclear Issues,* (Palgrave Macmillan division of St. Martin's Press, LLC and Palgrave Macmillan Ltd. 2008).

23. Ka Po Ng. *Interpreting China's Military Power: Doctrine Makes Readiness,* (Published by Frank Cass, an imprint of Taylor & Francis, 2005).

24. Thomas Mahnken argues that the Chinese and American interaction of arms is more complicated that just matching weapons and effects. While it is true the Chinese have developed weapons to counter U.S. threats or regional hegemony, other factors of consideration must be takin into account. Historical conflicts purported by scholars and military officials to promote cause and effect of U.S. actions versus Chinese response of particular interest include: the United States nuclear threats to China in the 1950s, the end of the Cold War, the rapid U.S. Gulf War victory, the Taiwan Strait Crisis of 1995-96, and the bombing of the Chinese Embassy in Belgrade. However, while true the United States and China generally respond to one another's presumed provocative actions (such as the nuclear threats of the 1950s), other factors such as Sino-Soviet Union relationship dynamics, country bureaucratic processes, country domestic affairs and changing security environment also play a role in how the Chinese and the United States may react to one another. For example, the Chinese development of conventionally armed ballistic missiles that threaten Taiwan and U.S. naval and land forces in the Indo-Pacific region originally were meant to counter Russian border operations and to provide an export revenue.

Concurrently, as much as U.S. policy makers would like to classify China into a specific category, Andrew Wilson (a professor of strategy and policy at the Naval War College) summarizes the Chinese way of strategy making as one of not having a single focus. Wilson promotes five Chinese strategies for discussion: The Great Wall Myth, the Sun Tzu Myth, the Good Iron Myth, the Zheng He Myth and the Myth of Shi.

The Great Wall Myth advocates that China should be viewed as a defensive nation. This position is rooted in Confucianism and *The Art of War* excerpts in order to conjure images of the Chinese only directing war when internal rebellion or defense of the territory is necessary. However, these views do not conveniently align with past Chinese's military actions and annexation of territory throughout its history. In a similar argument, the Sun Tzu Myth points to the Chinese philosophy of winning the war without fighting. However, this myth also does not ally with the nature of the Communist Party under Mao Zedong that admittedly promoted revolution through acts of violence.

The third myth, the Good Iron Myth, implies that the Chinese tend to value civilian bureaucracy over military governance and thus allocation of scholarly men and resources are to civilian tasks vs military entities. However, China's military successes and internal fights prove that this myth is also fraught with oversimplification or untruth. Similarly, the Zheng He Myth states that the Chinese do not have expansionism in their DNA. However, examples of gunboat diplomacy provide counter to this narrative as do more recent settlements of key strategic positions in Africa and the South China Sea.

The final strategy myth of interest is that of the Shi Myth, as referenced a number of times in *The Art of War,* but it appears to have different meanings depending on context. Authors have attempted to translate the notion of *Shi* as something unique to Chinese culture and as a course of "strategic advantage." The true definition of *Shi* may mean different things to different people both inside and outside China or simply manifest itself as a special gift from God to enable a clear strategy. In each instance *Shi* does not appear to be particularly helpful in predicting future strategic actions. Furthermore, the Chinese have not isolated themselves completely for the past 70 years and thus a pure form of *Shi* seems unlikely. For example, Mao exposed himself to the readings of Clausewitz and was an avid follower of Marxism and Lenin, clearly not a pure Chinese culture interpretation of *Shi*. Therefore, if the five common myths of Chinese strategy are systematically inapplicable, the next logical course of action is to examine what specific examples the Chinese leadership state regarding doctrine.

25. Richard D. Fisher, Jr., *China's Military Modernization: Building for Regional and Global Reach*, (Redwood City, Calif.: Stanford University Press, 2010).

26. Kyle Mizokami, "China Conducts New Hypersonic Weapon Test: Beijing Hopes Hypersonic Weapons Will Help It Leap to Parity with The U.S. Military," *Popular Mechanics*, Aug. 7, 2018, downloaded from www.popularmechanics.com/military/weapons/a22665761/china-conducts-new-hypersonic-weapon-test, accessed Jan. 5, 2019.

27. Eleni Ekmektsioglou, "Hypersonic Weapons & Escalation Control in East Asia," *Strategic Studies Quarterly*, vol. 9, no. 2 (2015).

28. Michael M. Maazar*, Understanding Deterrence,* (Santa Monica, Calif.: RAND Corporation, 2018).

29. Thomas Schelling *Arms and Influence*, Center for International Affairs. (New Haven, Conn.: Yale University Press, 1966).

30. Herman Kahn, *On Thermonuclear War*, (Princeton, N. J.: Princeton University Press, 1960).

31. Thomas Schelling *Arms and Influence*, Center for International Affairs, (New Haven, Conn.: Yale University Press, 1966).

32. Herman Kahn, *On Thermonuclear War*, (Princeton, N. J.: Princeton University Press, 1960).

33. The United States currently operates 14 Ohio-class SSBNs, an ICBM force consists of 400 single-warhead Minuteman III missiles, 46 nuclear-capable B-52H and 20 nuclear-capable B-2A "stealth" strategic bombers. The B83-1 and B61-11 gravity bombs can hold at risk a variety of protected targets while the ALCMs on the B-52H can permit the bomber to stay outside adversary air defenses and remain effective, NPR, 2018.

34. Office of the Secretary of Defense, *Nuclear Posture Review* (Washington, D.C.: Department of Defense, 2018), www.defense.gov.

35. Vipin Narang, *Nuclear Strategy in The Modern Era, Regional Powers and International Conflict,* (Princeton, N.J. and Oxford: Princeton University Press, 2014).

36. Richard D. Fisher, Jr., *China's Military Modernization: Building for Regional and Global Reach*, (Redwood City, Calif.: Stanford University Press, 2010). Originally taken from Information Office of the State Council of the People's Republic of China, *China's National Defense in 2006,* Beijing, China, December 2006.

37. Major General (retired) Pan Zhenqiang, as of August 2017 was deputy chairman of the China Foundation for International Studies, senior adviser to the China Reform Forum and director of research at the Institute for Strategy and Management of the Central University of Finance and Economics in China.

38. Major General (retired) Pan Zhenqiang, "A Study of China's No-First-Use Policy on nuclear Weapons," *Journal for Peace and Nuclear Disarmament*, vol. 1, no. 1, (2018), p. 115-136.

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CHAPTER 4

Hypersonic Highly-Maneuverable Weapons and Their Effect on the Deterrence Status Quo

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In 1945, man learned to control and harness the splitting of the atom and fashioned this newfound knowledge into a weapon whose massive destructive properties overshadowed the combined power of every other weapon ever designed. The result was the utter annihilation of two Japanese cities and the end to nearly a decade of worldwide warfare. Little Boy and Fat Man signaled the end of World War II and simultaneously heralded the beginning of the Nuclear Age. As the first creator of these weapons, the United States enjoyed a brief period as a hegemonic power of a unipolar world. However, the Russian raced to regain their place of world influence in the late 1940s when they developed and tested a nuclear device of their own.[1] This ignited a fierce competition as these two countries sought to remake the world after their own image. Soon, other countries joined the race to nuclear arms, which would eventually grow to eight participants (United States, Russia, China, France, England, India, Pakistan, North Korea) and one commonly accepted (Israel) nuclear-armed nations.

This list excludes South Africa as the South Africans have since dissolved their nuclear program. Of these nuclear states, the United States, Russia and China have far exceeded the other nations in accumulated weapons and means of delivery. The power struggle between these three world powers has spurred advances in technology that has led to physically smaller weapons with much greater yields and progressively advanced delivery systems to project this power. These advances in technology have now culminated in the United States, Russia and China each developing its own independent hypersonic and highly-maneuverable (HS/HM) weapons programs. These weapons are designed to penetrate any existing or pending defensive systems such that each country can ensure its continued ability to deter a nuclear strike from its rivals. However, it is not clear that all three countries need hypersonic or highly-maneuverable weapons to guarantee their deterrent posture and it is possible that these weapons could instead be an unnecessary acquisition that will only serve to destabilize the current status quo.

Understanding Hypersonic Capabilities in Context

This research project is focused on answering the following question: *How does the development of HS/HM weapons impact the nuclear deterrence status quo?* This project will look at current deterrent postures, capabilities, and policies for these three countries and assess to what extent these weapons provide a stabilizing or destabilizing effect.

Fortunately, there has been extensive literature published on the subject of hypersonic/highly-maneuverable weapons as well as the deterrence postures and polices for all three target countries. A primary source of this research revolves around a 2017 report from the RAND Corporation titled "Hypersonic Missile Nonproliferation."[2] RAND is a reputable corporation that has produced copious military reviews on technologies and strategies, among other issues, for multiple agencies and organizations including Congress. This report reviews at length the technologies involved, the difficulties in maintaining a HS/HM program and the progress made by the three target countries. This document also describes strategies for employment and likely targets for and uses of HS/HM weapons. Finally, this section will also use "Employment of Hypersonic Glide Vehicles" by Able Olguin, the "Nuclear Posture Review" and the "National Defense Strategy" to provide additional background on strategies and policies regarding HS/HM weapons and nuclear deterrence in general.[3]

The Missile Defense Project (MDP) is another primary source that provides current capabilities and limitations for each of the three target countries. The Missile Defense Project provides copious information on current and retired offensive and defensive weapons. This information largely reviews and informs on strategy implications to current deployments.[4] MDP maintains a current database with most information reviewed having been updated last in June 2018.

Several scholarly articles were used to provide background on deterrence policies and motivations for each country to pursue HS/HM programs. Noted scholars reviewed in this section that have not already been mentioned include: Abigail Stowe-Thurston, Matt Korda & Hans M. Kristensen who discuss Russian nuclear policy and its implications; Brad Roberts who has written extensively on deterrence issues and nuclear policy; Bruno Tertrais who has written on the relevancy of nuclear deterrence; Kristin Ven Bruusgaard who delves into Russian strategy regarding nuclear deterrence; Rajaram Nagappa who analyzes the negative implications of HS/HM development and fielding; Zhenqiang Pan who specifically addresses Chinese policy on nuclear weapons and deterrence; and Vipin Narang who writes extensively on deterrence relationships and policy.

The literature review for this project has been extensive and representative of multiple views regarding nuclear deterrence and HS/HM development. While this literature review cannot possibly encompass every view point on these topics, the works selected represent scholarly and peer-reviewed articles, published books and commissioned reports in addition to fact-based literature involving specific systems employed.

Prior to analyzing the implications of HS/HM programs, it is important to understand the terminologies and technologies involved. The term "hypersonic weapon" carries common misconceptions regarding what exactly is being discussed. Often, people use the term "hypersonic weapon" to describe new and emerging technologies while overlooking currently fielded systems that meet the criteria to be considered hypersonic weapons. The first section of the research will focus on defining specific areas of hypersonic weapons development and its corresponding technologies that are directly applicable to this project. This section will clearly define terms and provide a narrow and scoped focus on the subsect of hypersonic weapons that are also highly-maneuverable.

The paper will then dive deeper into the technological aspects of HS/HM programs and the challenges to any country that desires to build a successful program. This section will cover technological and financial challenges to creating an enduring program. The section will also look at the feasibility of mass production of HS/HM assets.

The term "hypersonic weapon" has been commonly misused to only apply to new technologies such as cruise missiles and hyperglide vehicles currently under development and testing. Technically speaking, a hypersonic vehicle is any vehicle that travels in excess of five times the speed of sound, or Mach 5.[5] Using this definition, several existing ballistic weapon systems are categorized as hypersonic weapons including the current stockpile of intercontinental ballistic missiles (ICBM) currently fielded by Russia, China and the United States. These missiles deliver ballistic warheads that impact or detonate at speeds in excess of the Mach 5 threshold for hypersonic weapons.

However, this project specifically focuses on weapons that are hypersonic and also highly-maneuverable (HS/HM) and includes new weapons under development such as boost-glide, hyperglide and hypersonic cruise missiles, which are specifically designed to travel "between 5,000 and 25,000 kilometers per hour, or one to five miles per second" and "defeat adversary defensive systems" through a combination of speed and maneuver.[6] The addition of a highly-maneuverable aspect to these weapons changes the implications for the development of this new technology, which will be discussed later. Before discussing the strategic military and political implications of this new technology, it is important to look at the current deterrence posture and deterrent policies of these three countries.

As this project looks at the ability of these new weapons to penetrate existing and projected missile defenses, it is sufficient to limit this discussion specifically to the intercontinental ballistic missile systems from each country excluding current air-launched or sea-launched weapons as it will become evident that existing ballistic missiles maintain and are projected to maintain the capability for each country to penetrate the defenses of each other country regardless of additional sea- or air-based systems.

Hypotheses

Russia, China and the United States have all developed nuclear arsenals with the stated goal of assuring a massive retaliatory strike against any potential nuclear aggressor. As a result, each country has diversified its delivery systems and fielded nuclear weapons in such quantities as to make their assurances reality. Each country currently possesses nuclear weapons in such quantity as to have a guaranteed ability to overwhelm any currently fielded or planned defensive systems such that a massive retaliatory strike is assured regardless of the development of new delivery systems technology. As a result, I hypothesize that while hypersonic/highly-maneuverable weapons represent a leap in delivery system technology, they do not fundamentally provide a new capability to guarantee an assured second strike and therefore their physical capability does not change the deterrence status quo. However, as HS/HM weapons are naturally offensive in nature, continued development of an HS/HM program by any country creates possible misperceptions surrounding that country's intentions regarding the deterrence status quo that may be destabilizing.

Hypothesis 1: *The physical capability of hypersonic/highly-maneuverable weapons will not significantly change the deterrence status quo in the international system, holding all else constant.*

Hypothesis 2: *Misperceptions about the intentions of the development of these weapons systems may increase instability in the deterrence status quo.*

Now that HS/HM weapons have been properly defined, the remainder of this paper focuses on the deterrence postures and policies for each of the target countries to provide a look at where each country currently stands prior to introducing HS/HM weapons into its inventory. This review will also include a look at the historical policies for each country regarding the employment of nuclear weapons as a means to provide a contrast to potential policy implications once HS/HM weapons are introduced.

Finally, this project will extrapolate policy implications for each country based on this emerging technology. This section will address whether or not HS/HM weapons represent a new capability and how that new capability, if it exists, would likely be employed by each country. This will contain a brief review of current policies for each country and the natural evolution of these policies to meet a potential new threat. Specifically addressed will also be the perceptions of each country and the others' intentions and how that perception may or may not destabilize the current nuclear deterrence status quo.

U.S. Current Posture

The United States currently maintains 450 active LGM-30G Minuteman III intercontinental ballistic missile silos with a slightly lower number of these silos containing active on-alert missiles with deliverable warheads.[7] The United States does not maintain or operate any other land-based ICBMs. Additionally, the United States maintains several missile defense systems, though the one most pertinent to this research is the ground-based midcourse defense (GMD) system.[8] GMD is the primary system used to defend the United States against incoming long-range ballistic missiles and is comprised of 44 interceptor missiles.[9] This system is designed to intercept incoming missiles at great distances. The United States also maintains two regional missile defense systems, the Terminal High Altitude Area Defense (THAAD) and Aegis. While both systems can contribute capabilities to long-range missile defense, mainly in tracking and warning, they are not viable to provide a reliable long-range defense as these systems are designed for short- to intermediate-range missile defense and need to be closer to the point of launch than GMD to be effective.[10] Therefore their numbers and deployment are inconsequential to this discussion. Finally, the Army, Air Force and Navy have decided to collaborate to develop a hypersonic glide body that would meet the definition of an HS/HM weapon in response to development of such weapons by Russia and China.[11] The first weapon is "predicted to be operational by 2022."[12]

Also relevant to this project are U.S. policies regarding the use of nuclear weapons. U.S. nuclear policy is discussed in multiple documents, the most relevant to this discussion are the Nuclear Posture Review (2018) and the National Defense Strategy (2018). Both documents discuss the deployment, sustainment and potential use of nuclear weapons and specifically address their role in deterrence.[13] Both documents address the United States policy of use of nuclear weapons to deter both nuclear and non-nuclear aggression multiple times. Nowhere does the document explicitly state the United States has a no-first-use policy, but the overall tone of both documents indicate that nuclear weapons will only be used in response to aggression.[14] While no-first-use policies typically refer to the first use of a nuclear weapon, most countries, including Russia and China, have expanded this meaning to include the first use of any devastating weapon, not exclusive to a nuclear weapon, that threatens a nation's vital interests. This could include weapons commonly thought of as weapons of mass destruction such as chemical, biological or radiological weapons, but could also now include cyber and large-scale conventional attacks, especially if these attacks threaten a nation's nuclear systems or nuclear command and control network.[15] The current U.S. capabilities and posture support the ability of the United States to respond to all these scenarios with a robust second-strike capability that keeps the deterrence status quo that has carried the major powers from World War II, through the Cold War and to the present.

Russia's Current Posture

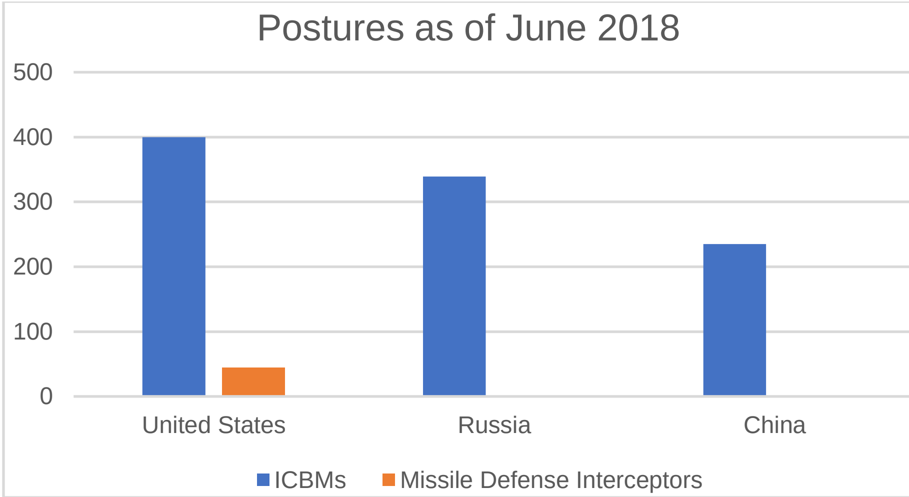
Russia currently has fielded six different ICBM systems excluding those systems that have been retired or are currently in development, but are not operationally deployed. Like with the United States, this number excludes air- and sea-launched systems as well as any missiles of less than intercontinental range. Of these six deployed systems, Russia has approximately 349 ICBMs deployed, some with multiple independently targeted reentry vehicles (MIRV).[16] Russia does not currently have a missile defense system and does not have plans to field such a system. However, Russia has been actively developing HS/HM weapons to include cruise and intercontinental missiles.[17]

Russian policy on nuclear use has been consistent over the last decade with President Vladimir Putin declaring publicly that Russia "reserves the right to use nuclear weapons only in response to 1. a weapon of mass destruction (WMD) attack against Russia or its allies or 2. a conventional attack that existentially threatens the Russian State,"[18] (from the English translation of his remarks). However, President Putin also stated in a later interview that "Russia reserves the right to use nuclear weapons only in response to a nuclear attack on Russian territory."[19] While these two statements are somewhat contradictory, they both translate loosely into a no-first-use policy though, again, this does not strictly mean that Russia will not use a nuclear weapon until another country first uses a nuclear weapon, but rather that nuclear weapons will only be used as a response to an overwhelming conventional or nuclear attack that threatens to limit Russian response capabilities. Further, Russian military doctrine discusses several times how nuclear weapons will be used to deter both nuclear and conventional large-scale warfare, which again supports the concept of no-first-use.[20] In short, current Russian capabilities and posture support the deterrence status quo by maintaining a guaranteed retaliatory strike capability. However, its development of HS/HM weapons indicate a perception that Russia fears it will not be able to overcome U.S. missile defense systems.

China's Current Posture

China currently maintains approximately 235 missiles of intercontinental range.[21] Like with Russia, China's ICBM fleet is comprised of several different designs, some of which are designed to carry MIRVs.[22] As discussed with the United States and Russia, this number does not include sea- or air-launched systems and also excludes short- and intermediate-range missiles. China also does not currently have a missile defense system fielded nor do it have plans to acquire such a system. Though, like the other two great powers, China has an advanced hypersonics weapons program that is developing both cruise missiles and reentry vehicles that could be carried atop intercontinental missiles.[23] At least one of these systems is currently slated to enter initial operating capability by 2020.[24]

China's nuclear policy has been clear and unambiguous for several decades. China stands firm on a no-first-use policy and maintains that its nuclear weapons are solely for self-defense.[25] "Though Chinese strategists have long debated the merits of shifting from what they term a 'minimum deterrence' doctrine to a more aggressive 'limited deterrence' doctrine, that fields theatre nuclear capabilities for possible first use, there has in fact been remarkable continuity in China's nuclear posture."[26] This policy differs from American and Russian policies in that there are no explicitly stated provisions for use of nuclear weapons in a conventional conflict, even if that conflict is aimed at nuclear command and control. In fact, "China has shown remarkable consistency in its posture of assured retaliation, but (has) focused on retaliation to a nuclear strike. The Chinese effort to improve capabilities over the past several decades has focused on survivability and penetration in response to U.S. capabilities to ensure that China maintains the forces required to guarantee nuclear retaliation following a first-strike effort by an adversary."[27] However, like Russia, China's development of HS/HM weapons signals a Chinese perception that U.S. missile defenses could eliminate China's ability to guarantee a retaliatory strike against the United States.



Implications of HS/HM Weapons Development

Prior to the development of HS/HM systems, the threat of nuclear engagement has prevented any overt major power conflict for more than 70 years, primarily using bombers and ballistic intercontinental missiles (including submarine-launched ballistic missiles).[28] "No comparable period of time has ever existed in the history of the States."[29] It is also understood that "there has never been direct military conflict between two nuclear states" and that "no nuclear-armed country has ever been invaded."[30] However, this lack of conflict could also be predicated on the notion that nuclear-armed nations maintain credible and assured second-strike capabilities that prevent other nations from attacking their countries or their allies without facing an overwhelming and devastating counterattack by the aggrieved party. The United States maintains a triad of intercontinental ballistic land-based missiles, bombers and submarines in order to guarantee its retaliatory capability. Russia and China each rely on similar postures to ensure that no first strike has the possibility of eliminating its second-strike capability.

HS/HM weapons create a new dynamic in nuclear warfare due to the physical characteristics that differentiate these weapons from existing delivery systems. HS/HM weapons "couples the high speed of ballistic missiles with the maneuverability of aircraft."[31] The ability to maneuver at such high speeds changes several aspects to how countries implement their deterrent postures. A ballistic warhead delivered from a traditional intercontinental ballistic missile travels in a highly parabolic arch along a predictable flight path. These warheads are detectable and the predictability of where they will strike allows an adversary to achieve some level of planning for a retaliatory strike before the first strike hits based on known quantities. Ballistic missiles with MIRV capabilities leave some ambiguity as to the predicted target, but only to a limited extent, and even after warhead release from the delivery system, there is a significant amount of time where the warhead is able to be tracked and targeted by missile defense systems. Conversely, "unlike current ballistic missiles, (HS/HM weapons) can vary their impact point" drastically more than traditional systems.[32] HS/HM weapons also "fly at unusual altitudes – between a few tens of kilometers and 100 kilometers. These characteristics of high speed, maneuverability, and unusual altitudes make them both challenging to the best missile defenses now envisioned and, until the last minutes of flight, unpredictable as to their target."[33] HS/HM systems deployed on traditional intercontinental systems are boosted into flight like a traditional warhead, but quickly descend to a drastically lower altitude while maneuvering to avoid missile defense tracking and targeting systems. Air-launched HS/HM systems are deployed like traditional cruise missiles, but travel at much greater velocities while maneuvering to also avoid tracking and targeting defensive systems. These capabilities combine to provide an aggressor with an almost assured ability to penetrate an adversary's defensive systems with a limited number of weapons to achieve a specific objective. An attack using HS/HM weapons could also go undetected by the attacked nation until moments before impact, which reduces warning and reaction time as "a radar operating from the surface of the Earth would detect a 3,000-kilometer range reentry vehicle (RV) about 12 minutes before impact, but would not detect an HGV until about six minutes before impact."[34]

Challenges with HS/HM Weapons

Like with any new technology, HS/HM systems are costly to build due to technology limitations and the extreme environments in which these systems operate.[35] "The envisioned military value of hypersonic delivery systems lies in their ability to strike quickly over long distances while evading early-warning radars and ballistic missile defenses."[36] The speed necessary to travel these distances in so short a period of time require immense efforts to produce a vehicle that can survive such a dynamic and harsh environment. "The persistent high speed and long atmospheric flight time of hypersonic vehicles result in an extremely severe operating environment requiring advanced new systems, components, materials, design tools, and test facilities."[37] The first issue with creating such a vehicle is the management of thermal stress and manufacturing those materials to help mitigate this process.[38] Despite traditional ballistic warheads also achieving hypersonic speeds at detonation, the operating environment for a HS/HM weapon is much different. For example, a ballistic warhead experiences extreme and instantaneous heating for a very short period of time.[39] However, a HS/HM weapon experiences higher temperature for several times longer than a ballistic reentry vehicle.[40] This aerodynamic heating coupled with the compact size of the HS/HM weapon "make it more difficult to maintain their structure and internal components below their upper temperature limits."[41] In addition to issues with internal structures and components, these environments can warp, bend or break control surfaces.[42] Further, "the high temperature environments will also create challenges … for sensor and communications systems," which are necessary for the vehicle to ascertain its position and velocity to make course corrections and maneuver accordingly.[43]

In addition to issues with thermal management, the research and development infrastructure for ground testing is extraordinarily expensive.[44] This is a significant barrier to smaller nations with smaller budgets that may prevent these countries from even contemplating a HS/HM program, and this may also serve as a deterrent to mass production of these systems by larger countries as the initial cost to establish such an infrastructure may prevent these countries from fielding a mass-produced system.[45] To mitigate this particular issue, most countries would seek to combine military and commercial efforts to help drive the cost down to construct the research and development infrastructure.[46] Although, this approach in itself has issues as commercial industry has not seen fit to invest heavily in the necessary technologies that would benefit a military program. A prime example is the commercial failure of the Concorde passenger plane. The "business case for the Mach 2 Concorde, was at best, marginal, and the factors that worked against the business case would be multiplied for hypersonic airliners.[47] Flights on the Concorde were discontinued after just a few years as there was no commercial drive to keep it going. This is considering that the Concorde is a supersonic aircraft and does not have some of the more severe limitations of a hypersonic aircraft. The Concorde was already an expensive program and yet it did not have to deal with the engineering feat of creating a propulsion system that could transition between subsonic and hypersonic flight.

Russian and Chinese Perceived Need for HS/HM Weapons

Russia and China both have similar concerns when it comes to U.S. missile defense that has led each of these two countries to aggressively pursue its own HS/HM programs. Russia specifically highlights "American military-technological advances" including its ballistic missile defense program as an area of concern in relation to deterrence.[48] The Russian perception is that the United States' development of the BMD system is part "of an effort to achieve global military supremacy, and (is) a risk, therefore to strategic stability."[49] Russia has always relied on its nuclear weapons to "deter aggression by threatening to inflict unacceptable damage on any potential aggressor in a retaliatory strike."[50] The Russians "reliance on the nuclear deterrence of both nuclear and conventional threats has been part of official Russian military doctrine since 2000."[51] Especially in light of combined NATO forces, Russia does not have the ability to field a superior conventional force, which has driven them to rely on a "coupling of Russia's nuclear weapons and its great-power status" which has in turn created a situation where "any development that could undermine Russian deterrence (is) perceived to undermine Russia's position in the world."[52] The Russian perception is that American BMD systems represent a clear threat to Russia's current nuclear arsenal and its ability to execute an assured second strike. This has been a primary driving factor for Russia's perceived need for HS/HM weapons as Russia views this as the only means to defeat U.S. BMD systems and assure a retaliatory capability in a nuclear exchange.

Similarly, China is concerned with the American ability to render its nuclear force ineffective. China has been increasingly concerned with U.S. BMD as well as increasing U.S. abilities to effect precision strikes with both nuclear and non-nuclear forces, which it sees as threatening to its land-based missiles. American efforts to develop in these areas, "even though not directly linked to Chinese capabilities, created gaps in perceptions and exacerbated fears about intentions of the United States to contain China. According to Chinese experts, a few main reasons lurking behind Chinese concerns were the traditionally small size of its nuclear arsenal and that arsenal's questionable second-strike capability in light of the U.S. precision strike capability discussed earlier."[53] This is especially concerning to China as "Chinese missiles tend to be mainly liquid-fueled, with long periods of preparation before launch."[54] In their eyes, the Chinese are concerned with a U.S. ability to possibly strike their nuclear force prior to launch, and further concerned with the U.S. ability to use BMD to nullify any other missiles that China is able to launch in retaliation. "Specifically, Chinese experts talk about the scenario of China being subject to American coercion, a concern that is mainly due to U.S. nuclear superiority, which – married to BMD … puts at risk Chinese retaliatory capability.[55] As a result of these concerns, China has aggressively pursued its own HS/HM program aimed at modernizing its nuclear force while still maintaining what the Chinese consider to be a "lean and effective deterrent" aimed at upholding its no-first-use doctrine while remaining credible in the realm of an assured second strike.[57] The Chinese see an effective HS/HM as an essential means to penetrate U.S. missile defenses in light of the U.S. BMD system. Like Russia, China's conventional forces do not currently match U.S. forces in capability, which drives the Chinese to rely heavily on their nuclear forces to prevent major war conflict.

Both Russia and China perceive the U.S. BMD system to be a significant threat to their nuclear second-strike capabilities and this perception has led to them both developing HS/HM systems. Both countries perceive that HS/HM weapons are the only viable means to guarantee penetration of U.S. defenses. Based on this premise, both countries see HS/HM weapons as critically essential to maintaining an effective deterrence status quo.

U.S. Perceived Need for HS/HM Weapons

The United States does not have a case for using the same rationale for its pursuit of HS/HM weapons. Neither Russia nor China possess a BMD system and are not in the process of starting BMD programs. This complicates the U.S. case for development of HS/HM weapons as "hypersonic missiles do not necessarily increase the vulnerability of nations that do not have missile defenses; they are already vulnerable to current types of missiles."[58] Further, any attempt by Russia or China to eliminate U.S. retaliatory capability in a first strike would involve the entirety of each country's nuclear stockpiles, making this an extremely unlikely scenario. This means that the United States would maintain a credible assured second-strike capability even in the face of a massive first strike by either Russia or China even without HS/HM weapons. As the United States does not have a clear need to develop HS/HM weapons, its intentions for continued development of its HS/HM program are unclear leading to several possible conclusions that will be discussed later.

Misperceptions of Current Capabilities

With all the issues surrounding development of HS/HM weapons, it can be puzzling as to why a country would pursue such a costly system. Every country has its own individual reasons for either pursuing a HS/HM program or not. As has been discussed earlier, both the Russians and Chinese believe U.S. BMD systems threaten their national security and have become increasingly concerned that U.S. conventional and nuclear systems could affect a decapitating first strike while simultaneously using ballistic missile defense to deny a retaliatory strike and win a nuclear confrontation. However, this belief is based on several misperceptions of the operational environment on all sides. First, the Russians and Chinese both believe that BMD systems threaten their ability to guarantee a second strike. Both countries have tied their national prestige on the international stage and their status as great world powers to their nuclear weapons programs and now believe that their nuclear deterrents may be becoming obsolete. The Russians in particular are "severely paranoid about U.S. missile defense … and are particularly worried about command and control decapitation and coercion in a crisis."[59] However, this is based on the perception that U.S. defense systems have rendered Russian and Chinese offensive nuclear systems null and void. As stated earlier, the primary concern of both Russia and China is in penetrating the U.S. ballistic missile defense shield to guarantee a retaliatory strike. Yet, the United States currently possesses only 44 ground-based interceptors designed to defend against the long-range missile threat from these two countries. As Russia currently possesses more than 300 intercontinental nuclear missiles while China has more than 200 systems, existing Russian and Chinese weapons both independently outnumber American interceptors. Even if the U.S. ground-based interceptors had a perfect 1:1 kill ratio, they would only be able to take down 44 adversary warheads. The 300-plus Russian and 200-plus Chinese missiles does not even account for any of these weapons that are currently armed with MIRVs or onboard countermeasures such as decoys or chaff. The United States would have to operationally deploy more than 150 additional interceptors to defeat a concerted strike from either nation even based strictly on a 1:1 kill ratio. It is evident that HS/HM weapons provide a more efficient means to penetrate U.S. defense systems with a greater number of warheads, but there is not a realistic ***need*** for these weapons as both Russia and China possess current delivery systems in sufficient quantity to overwhelm U.S. defenses and deliver an assured catastrophic retaliation to any aggression.

Additionally, United States development of HS/HM weapons relies on a misperception of the operating environment and what is currently achievable. As the RAND report on hypersonic weapon nonproliferation states, "hypersonic missiles, if used against nations with limited strategic forces, might disarm target forces before they can react."[60] However, as discussed earlier, both Russia and China have diversified their nuclear arsenals and dispersed their weapons in such a way as to make a decapitating strike extremely difficult and unlikely. Any attempt at a decapitating strike would involve a robust HS/HM program with mass production capabilities that would make such a program financially unfeasible.

Are HS/HM Weapons Destabilizing?

It has been demonstrated that none of the great nuclear powers require HS/HM weapons to achieve a credible retaliatory strike capability. The volume of both Russian and Chinese current land-based ballistic missile arsenals taken individually make each countries' second-strike capability unquestionable. There is no established need for either country to develop HS/HM weapons as a means to assure this capability. Using current capabilities and fielded forces, the United States, Russia and China all maintain robust nuclear deterrence forces that maintain the established status quo that has prevented great-power conflict for seven decades. From a strictly technological aspect, HS/HM weapons have not altered each countries' ability to achieve a credible retaliatory capability and as a result have not fundamentally changed the deterrence status quo from this perspective. However, as HS/HM weapons create new capabilities and alter how decisions are made and how long a country has to make a retaliatory decision, these weapons are seen as more threatening and aggressive than current fielded forces. This perception has the potential to destabilize the status quo.

As these weapons are significantly harder to track and terminate than traditional ballistic warheads and as they create a shortened timeline to make a retaliatory decision prior to receiving a potential first strike, they are seen as naturally offensive weapons that are far more threatening and aggressive. As described earlier, a country at risk of receiving an HS/HM attack has a significantly reduced timeline (from the point of detecting an incoming HS/HM weapon and warning) to make a decision as to a retaliatory strike prior to receiving the first hit. Complicating matters further, the aggrieved country has little capability to determine the most likely impact point of such a strike meaning any retaliatory efforts are not likely to be calculated to achieve a proportionate response making any retaliation naturally disproportionate. These issues complicate the decision-making process for a threatened country, which will likely drive changes to that country's deterrence posture.

The most concerning aspect of this new calculus is the possibility of a country that is threatened by HS/HM strikes to adopt a "launch-on-warning posture" or a possibility of moving towards a policy of preemptive strike.[61] A launch-on-warning posture relies heavily on a very robust and highly accurate warning apparatus that is not prone to misidentification of threats, which is dubious at best and a preemptive strike posture would fundamentally change the long-standing deterrence postures of the great nuclear powers. Both possibilities would lower the threshold for use of nuclear weapons in warfare and, especially in the case of a launch-on-warning posture, significantly increase the probability of accidental launch.

Of further concern is the threat that HS/HM weapons represent to no-first-use policies established by all three great nuclear powers. It is currently challenging to launch a preemptive nuclear first strike that could achieve decapitation of an adversary's forces based on an ability to detect and track an incoming warhead with sufficient time to make a decision on retaliatory measures prior to receiving the first strike. HS/HM weapons shorten that decision timeline significantly such that an aggressing country may believe it has a greater chance of achieving a successful first strike, even if the reality is that these weapons are extremely unlikely to be manufactured in such quantity as to confidently prevent a retaliatory strike. Any country that possesses a belief, even if that belief is not based in reality, that it can win a nuclear war increases the probability of that country using these weapons in an offensive and coercive manner to achieve its objectives. This also lowers the threshold for the use of nuclear weapons in warfare.

An offensive and coercive posture, or the perception of such a posture enacted by one country is conducive to more aggressive defensive and offensive counter-posturing by another country. While it has been demonstrated that the development of HS/HM technology does not threaten the retaliatory capability of any of the great nuclear powers, the perceptions surrounding decisions to pursue such a program lead to misperception of intentions that appear to be aggressive and hostile, which in turn has the significant potential to destabilize the deterrence status quo.

Conclusions

Hypersonic/highly-maneuverable weapons represent a leap in the technological efficiency of nuclear delivery systems. These weapons travel at such a speed and possess a maneuverability to make them difficult to detect and track. However, due to the engineering difficulty and the materials needed, which drive a significant cost for such a program, it is highly unlikely that any country will manufacture these weapons in such a quantity as to threaten the current deterrence status quo. As a result, it is not the technology itself, but the perceptions of the intentions surrounding HS/HM programs that challenges the stability of the nuclear deterrence model. The lack of understanding of great nuclear power nations' intentions regarding HS/HM weapons has the most potential to destabilize the deterrence status quo and lower the threshold for the use of nuclear weapons.

Notes

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CHAPTER 5

Conclusions

The papers in this manuscript have thoughtfully explored the link between technological innovation and strategic thinking in the context of hypersonic weapons development. Taken together, they yield several conclusions and policy recommendations.

Firstly, each of the three papers showed the need for more serious discussion and planning around for what purpose the United States will use hypersonic weapons. Each branch of the military has indicated interest, but there is no clear strategy for how and when they will be used. Further, especially given the Russian and Chinese interest in nuclear-capable hypersonic systems, there needs to be a clearer whole-of-government approach to thinking through the implications of pursuing conventional-capable hypersonic weapons only. In a similar vein, a frank discussion of allocating budgetary resources to the development and deployment of hypersonic weapons is also warranted.

Secondly, the chapters in this book have shown that it would be prudent for leaders in the defense establishment to take a step back and think about the global implications of hypersonic weapons rather than barrel full-steam-ahead with budgetary planning. In different ways, each student answering the question of how hypersonic weapons will impact deterrence concluded that the weapons themselves will have no discernible impact, but rather, the *perception of intentions* by leaders in each country involved (namely the United States, Russia, and China) may prove significantly destabilizing to both deterrence and, more broadly, the global order.

With this in mind, policy recommendations center around the need for transparency from all governments involved. To the extent that it is possible, both Track I and Track II diplomacy could be useful for garnering this transparency. Where it can, the United States should seek to reassure Russia and China of its intentions around hypersonic propulsion technology development and request the same in kind. Further, an arms control treaty specifically for hypersonic weapons development should be negotiated. This can be a trilateral effort between the three major powers, or a more global initiative through the United Nations since both India and France are increasingly interested in these weapons systems, and R&D efforts are being actively pursued by Australia, Japan, and the European Union.[1]

Note

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