Calhoun: The NPS Institutional Archive

DSpace Repository

Theses and Dissertations | 1. Thesis and Dissertation Collection, all items

2023-03

THE PEN, THE SHIELD, OR THE SWORD? HOW THE UNITED STATES WINS THE HYPERSONIC ARMS RACE

Santacroce, Andrew E.

Monterey, CA; Naval Postgraduate School

https://hdl.handle.net/10945/72051

This publication is a work of the U.S. Government as defined in Title 17, United States Code, Section 101. Copyright protection is not available for this work in the United States.

Downloaded from NPS Archive: Calhoun

http://www.nps.edu/library

Calhoun is the Naval Postgraduate School's public access digital repository for research materials and institutional publications created by the NPS community. Calhoun is named for Professor of Mathematics Guy K. Calhoun, NPS's first appointed -- and published -- scholarly author.

Dudley Knox Library / Naval Postgraduate School
411 Dyer Road / 1 University Circle
Monterey, California USA 93943

NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

THE PEN, THE SHIELD, OR THE SWORD?
HOW THE UNITED STATES WINS
THE HYPERSONIC ARMS RACE

by

Andrew E. Santacroce

March 2023

Thesis Advisor: Erik J. Dahl
Second Reader: John J. Hammerer Jr.

Approved for public release. Distribution is unlimited.

THIS PAGE INTENTIONALLY LEFT BLANK

REPORT DOCUMENTATION PAGE	*Form Approved OMB No. 0704-0188*

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington, DC, 20503.

1. AGENCY USE ONLY *(Leave blank)*	**2. REPORT DATE** March 2023	**3. REPORT TYPE AND DATES COVERED** Master's thesis

4. TITLE AND SUBTITLE THE PEN, THE SHIELD, OR THE SWORD? HOW THE UNITED STATES WINS THE HYPERSONIC ARMS RACE	**5. FUNDING NUMBERS**
6. AUTHOR(S) Andrew E. Santacroce	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000	**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A	**10. SPONSORING / MONITORING AGENCY REPORT NUMBER**

11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release. Distribution is unlimited.	**12b. DISTRIBUTION CODE** A

13. ABSTRACT (maximum 200 words)

In the past few years, China and Russia have developed offensive hypersonic missile capabilities that the United States currently can neither match nor successfully defend against. Such weapons are nuclear capable, have an unpredictable flight path, and significantly reduce reaction times for decision makers. This thesis analyzes the impact hypersonic missiles have on strategy and military combat systems to determine how the United States can best respond to China and Russia acquiring hypersonic weapons. It explores three main options: arms control negotiations, advancing the U.S. missile defense system, or the United States acquiring its own hypersonic weapons. The pros and cons of each option are weighed to determine the quickest, most affordable, and most effective approach to the hypersonic arms race.

This thesis concludes that the United States should control only what it is capable of controlling: practicing transparency and confidence-building measures to set the international standard for conduct with hypersonic weapons, continuing to develop its missile defense system to keep pace with emerging threats, and acquiring hypersonic missiles to allow it the ability to operate forward-deployed forces without impediment is the best response to China and Russia.

14. SUBJECT TERMS national strategy, hypersonic, missile, defense, strike, policy	**15. NUMBER OF PAGES** 113
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT Unclassified	**18. SECURITY CLASSIFICATION OF THIS PAGE** Unclassified	**19. SECURITY CLASSIFICATION OF ABSTRACT** Unclassified	**20. LIMITATION OF ABSTRACT** UU

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

THIS PAGE INTENTIONALLY LEFT BLANK

Approved for public release. Distribution is unlimited.

THE PEN, THE SHIELD, OR THE SWORD?
HOW THE UNITED STATES WINS THE HYPERSONIC ARMS RACE

Andrew E. Santacroce
Lieutenant, United States Navy
BA, University of Texas, San Antonio, 2015

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF ARTS IN SECURITY STUDIES
(HOMELAND SECURITY AND DEFENSE)

from the

NAVAL POSTGRADUATE SCHOOL
March 2023

Approved by: Erik J. Dahl
Advisor

John J. Hammerer Jr.
Second Reader

Afshon P. Ostovar
Associate Chair for Research
Department of National Security Affairs

THIS PAGE INTENTIONALLY LEFT BLANK

ABSTRACT

In the past few years, China and Russia have developed offensive hypersonic missile capabilities that the United States currently can neither match nor successfully defend against. Such weapons are nuclear capable, have an unpredictable flight path, and significantly reduce reaction times for decision makers. This thesis analyzes the impact hypersonic missiles have on strategy and military combat systems to determine how the United States can best respond to China and Russia acquiring hypersonic weapons. It explores three main options: arms control negotiations, advancing the U.S. missile defense system, or the United States acquiring its own hypersonic weapons. The pros and cons of each option are weighed to determine the quickest, most affordable, and most effective approach to the hypersonic arms race.

This thesis concludes that the United States should control only what it is capable of controlling: practicing transparency and confidence-building measures to set the international standard for conduct with hypersonic weapons, continuing to develop its missile defense system to keep pace with emerging threats, and acquiring hypersonic missiles to allow it the ability to operate forward-deployed forces without impediment is the best response to China and Russia.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

I. INTRODUCTION 1

A. RESEARCH QUESTIONS 1
B. PROBLEM STATEMENT 1
C. LITERATURE REVIEW 2
1. Hypersonic Missiles Defined 2
2. Destabilizing Effects 3
3. What to Prioritize? 4
4. Conclusion 6
D. POTENTIAL EXPLANATIONS AND HYPOTHESES 7
E. RESEARCH DESIGN 8
F. CHAPTER OVERVIEW 8

II. TALE OF THE TAPE: HYPERSONIC STRATEGY, CAPABILITIES, AND LIMITATIONS 9

A. THE UNITED STATES 9
1. Strategy 10
2. Capabilities and Limitations 14
B. CHINA 18
1. Strategy 19
2. Capabilities and Limitations 21
C. RUSSIA 24
1. Strategy 24
2. Capabilities and Limitations 26
D. CONCLUSION 28

III. THE PEN: ENDING THE HYPERSONIC ARMS RACE WITH DIPLOMACY 29

A. ARMS CONTROL 29
1. Should the United States Pursue Arms Control? 30
2. Arms Control Measures/Agreements Available 32
3. Effects 35
4. Challenges 37
5. What Would Work? 38
B. CURRENT HYPERSONIC ARMS CONTROL MEASURES AND AGREEMENTS 41
1. Missile Technology Control Regime 42

2. New START 44
3. Other International Organizations and Bodies 45
4. Relatable Measures 46
C. HOW TO WIN WITH THE PEN 46

IV. THE SHIELD: WINNING THE HYPERSONIC ARMS RACE WITH AN EFFICIENT HOMELAND MISSILE DEFENSE SYSTEM 51

A. HOMELAND HYPERSONIC MISSILE DEFENSE CONSIDERATIONS 51
1. Requirements 51
2. Strategic Effects 55
3. Why the United States Needs an Efficient Homeland Hypersonic Missile Defense 57
4. Criticism 60
B. OPTIONS FOR DEFEATING HYPERSONIC WEAPONS 61
1. How to Defeat Hypersonic Missiles 62
2. What Could Work? 67
C. HOW TO WIN WITH THE SHIELD 69

V. THE SWORD: WINNING THE HYPERSONIC ARMS RACE BY ACQUIRING ITS OWN HYPERSONIC MISSILES 73

A. CONSIDERATIONS 73
1. Significant Impact to Strategic Stability 73
2. 2019 Hypersonic Weapons Tabletop Exercise Report 76
B. POTENTIAL CONSEQUENCES 77
1. Negative Strategic Effects 77
2. Cost 79
C. POTENTIAL BENEFITS 79
1. Positive Strategic Effects 80
2. Military Use 81
D. HOW TO WIN WITH THE SWORD 82

VI. HOW THE UNITED STATES WINS THE HYPERSONIC ARMS RACE 85

A. CONCLUSION 85
1. Establish TCBMs 87
2. Reject Mutual Vulnerability and Develop the Strongest Defense 88
3. One Common HGV and HCM 89
B. RECOMMENDATIONS FOR FUTURE RESEARCH 89

C. FINAL THOUGHTS 90

LIST OF REFERENCES 91

INITIAL DISTRIBUTION LIST 97

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF ACRONYMS AND ABBREVIATIONS

A2/AD	anti-access/area denial
AMRAAM	advanced medium-range air-to-air missile
ARRW	air-launched rapid response weapon
BMD	ballistic missile defense
C2	command and control
C2BMC	command, control, battle management, and communications
CBO	Congressional Budget Office
CPS	conventional prompt strike
EPAA	European phased adaptive approach
GMD	ground-based midcourse defense
HACM	hypersonic attack cruise missile
HALO	Hypersonic air-launched offensive
HASC	House Armed Services Committee's
HBTSS	hypersonic and ballistic tracking space sensor
HCM	hypersonic cruise missile
HCoC	Hague Code of Conduct against Ballistic Missile Proliferation
HGV	hypersonic glide vehicle
HTK	hit-to-kill
IADS	integrated air defense system
ICBM	intercontinental ballistic missile
IDA	Institute for Defense Analysis
LRHW	long-range hypersonic weapon
MDA	Missile Defense Agency
MDR	Missile Defense Review
MTCR	Missile Technology Control Regime
NDS	National Defense Strategy
NDSA	national defense space architecture
New START	New Strategic Arms Reduction Treaty
NORAD	North American Aerospace Defense Command

OUSD(R&E)	Office for the Under Secretary of Defense for Research and Engineering
PAC-3	PATRIOT advanced capability-3
PWSA	proliferated warfighter space architecture
SDA	Space Development Agency
SM	standard missile
TCBM	transparency and confidence-building measure
TCW	target centric warfare
THAAD	terminal high altitude area defense
UNIDIR	United Nations Institute for Disarmament Research
USNORTHCOM	United States Northern Command
USSTRATCOM	United States Strategic Command
WFOV	wide field of view
WMD	weapon of mass destruction

ACKNOWLEDGMENTS

Words cannot express my gratitude to my thesis advisor, Dr. Erik Dahl, for his invaluable patience and feedback. I also could not have undertaken this journey without my second reader, CAPT (Ret.) John Hammerer, who generously provided knowledge and expertise. Additionally, this thesis would not have been possible without the Meyer Scholar Program, which helped me grow professionally and personally as a student at NPS and as a surface warfare officer.

Last, but certainly not least, I would be remiss in not mentioning my family. Thank you to my beautiful wife, Veronica, for being my rock and inspiring me to work through tough times. I believe being both an amazing spouse and mother of three is the toughest job in the military, yet she makes it seem easy every single day. I would also like to thank my three amazing children, Abby, Austin, and Eli. Their daily reminders that there is always time to play, no matter how much work there is to get done, made this entire journey bearable. I love you all so much.

THIS PAGE INTENTIONALLY LEFT BLANK

I. INTRODUCTION

A. RESEARCH QUESTIONS

In the past few years, countries such as China and Russia have developed offensive hypersonic missile capabilities that the United States currently can neither match nor successfully defend against. Such weapons are nuclear capable, have an unpredictable flight path, and significantly reduces the OODA loop[1] for decision makers. To counter this threat, U.S. planners have several options available, including the proposal of a new arms control treaty that would include hypersonic missiles, the expansion of the homeland missile defense system, and the development of its own offensive hypersonic capability to promote deterrence. Given the limited resources available, how can the United States best address this threat? What option should the United States prioritize in order to gain an advantage in the hypersonic arms race against China and Russia?

B. PROBLEM STATEMENT

The United States is at a significant disadvantage compared to China and Russia when it comes to hypersonic capabilities. The speed, unpredictable flight path, low altitude, and nuclear capabilities of these missiles give U.S. leaders compressed decision timelines to determine the intent of a hypersonic missile launch. These characteristics are destabilizing to all nations worldwide. How can decision makers know if a hypersonic missile launch from China or Russia is a routine space launch or a hypersonic missile carrying a nuclear warhead heading towards the homeland? Making the correct decision in such a short amount of time will likely be difficult. For reference, a recent RAND report estimates that a terrestrial-based radar is only capable of detecting a hypersonic missile six minutes prior to impact.[2] U.S. deterrence relies on forward deployed military units all

[1] Observe, orient, decide, and act. A decision-making concept created by USAF Colonel John Boyd in 1976 and commonly used throughout the DOD today.

[2] Carrie Lee et al., *Hindering the Spread of a new Class of Weapons* (Santa Monica, CA: RAND Corporation, 2017), 12, https://www.rand.org/pubs/research_reports/RR2137.html.

across the globe, but that advantage erodes if they are susceptible to a hypersonic missile strike without any means of defense or counterstrike capabilities.

A problem of strategic proportion confronting the United States is how to maintain a robust deterrence strategy if it lacks the ability to defend against enemy hypersonic missiles and launch a counter strike using its own hypersonic missiles. This thesis explores three areas of focus that the United States should invest in in order to counter China's and Russia's current advantage in hypersonic weapons: seek arms control options, develop a missile defense system that can track and intercept hypersonic missiles, or field hypersonic missiles to bolster deterrence and diplomatic leverage. This problem will need to be answered realistically, as prioritizing all three options is monetarily impossible. This thesis seeks the best option, or combination of options, for the United States to take in order to catch China and Russia in the hypersonic arms race in the quickest and most feasible way possible.

C. LITERATURE REVIEW

This literature review provides an overview of published research and expert recommendations on what the United States should prioritize in order to counter our adversaries', specifically China and Russia, advantages in weaponized hypersonic technology. The first section will establish what constitutes as hypersonic technology and the importance of having a common description. Section two will explain the destabilizing effects hypersonic missiles have on countries. Section three will explore the literature on how the focus of arms control, missile defense systems, and hypersonic strike capabilities can grant the United States an advantage in the hypersonic arms race. The concluding section highlights the commonalities between the literatures and identifies other variables not mentioned by the experts that may be required for United States leadership in order to make the best decision possible.

1. Hypersonic Missiles Defined

To prevent any misunderstanding between policymakers, the media, and the general public, Kolja Brockmann and Markus Schiller define hypersonic missiles as missiles that travel at Mach 5 or faster and can conduct maneuvers while travelling that

quickly inside the atmosphere.[3] This is important to establish because there are plenty of weapon systems capable of achieving even faster speeds, like intercontinental ballistic missiles (ICBMs), but are incapable of maneuvering during flight. Masao Dahlgren and Tom Karako describe a hypersonic missile as the combination of the speed and range of a ballistic missile paired with the altitude and flight profile of a cruise missile.[4] Brockmann and Schiller also categorize hypersonic missiles into two subgroups: hypersonic cruise missiles (HCMs) and hypersonic glide vehicles (HGVs). HCMs maintain a constant speed and are self-powered throughout the entire flight pattern, while HGVs are typically launched via ballistic missiles and descend upon their target at high speeds.[5] Hypersonic missiles also have the capability to be armed with a conventional or nuclear warhead. These characteristics and subgroups are standard between experts and are utilized by all sources cited in this literature review.

2. Destabilizing Effects

Hypersonic missiles may create destabilizing effects worldwide because of their variable flight characteristics, current lack of defense against them, and the potential hair-trigger reactions that can be made in response to a launch. Karako and Dahlgren report that the high speed, quick maneuvering, and low altitude characteristics of hypersonic missiles are nearly undetectable for contemporary ground-based sensors the United States employs.[6] Larry Wortzel points to their dual-capability—meaning they can be nuclear or conventional—as a potential cause for using the incorrect form of retaliation due to the ambiguity of not knowing the type of warhead that was launched presents.[7] Carrie Lee et

[3] Kolja Brockmann and Markus Schiller, *A Matter of Speed? Understanding Hypersonic Missile Systems* (Stockholm: SIPRI, 2022), 3–4, https://www.sipri.org/commentary/topical-backgrounder/2022/matter-speed-understanding-hypersonic-missile-systems.

[4] Masao Dahlgren and Tom Karako, *Complex Air Defense: Countering the Hypersonic Missile Threat* (Lanham, MD: CSIS, 2022), 1, https://www.csis.org/analysis/complex-air-defense-countering-hypersonic-missile-threat.

[5] Brockmann and Schiller, 4.

[6] Dahlgren and Karako, 5.

[7] Larry Wortzel, *Hypersonic Weapons Development in China, Russia and the United States: Implications for American Security Policy,* Land Warfare Paper 143 (Arlington, VA: Association of the United States Army, 2022), 5, https://www.ausa.org/publications/hypersonic-weapons-development-china-russia-and-united-states-implications-american.

al. claim that hypersonic missiles reduce decision-making time so significantly that nations may revert to the "devolution of command and control of strategic forces, wilder dispersion of such forces, a launch-on warning posture, or a policy of preemption during a crisis."[8]

3. What to Prioritize?

There are three common options that are proposed by experts that the United States needs to prioritize in order to achieve an advantage in the hypersonic arms race against China and Russia: implement an arms control policy specific to hypersonic technology, develop a missile defense system capable of intercepting hypersonic missiles with a high success rate, and manufacturing hypersonic strike capabilities. This is not to say that the United States can only select one option, but realistically, it would not seem feasible to assume there are enough resources to select all three options and compete with China and Russia in a timely manner.

a. Arms Control

Arms control policy has been recommended by experts to slow the advancement of Chinese and Russian hypersonic technology and also to prevent the proliferation of hypersonic missiles by rogue states. Most scholars and experts suggest reforms to existing policy, but they generally suggest it as a secondary or tertiary option behind missile defense systems and hypersonic strike capabilities. Brockmann and Stefanovich argue that the best form of slowing the "arms race dynamic and the spread of hypersonic missile programmes" is to make reforms to the Missile Treaty Control Regime (MTCR).[9] He acknowledges the importance of offensive and defensive hypersonic capabilities but believes prioritizing the two results in "a vicious cycle, where missile defences lead to more missiles with an ability to defeat defences, which in turn lead to the development of more sophisticated defences."[10] Instead, the focus needs to be admitting China as an MTCR partner,

[8] Lee et al., xiii.

[9] Kolja Brockmann and Dmitry Stefanovich, *Hypersonic Boost-Glide Systems and Hypersonic Cruise Missiles: Challenges for the Missile Technology Control Regime* (Stockholm: SIPRI, 2022), v, https://doi.org/10.55163/BDYX5243.

[10] Brockmann and Stefanovich, 13.

promoting transparency about what is being launched, shoring up categorical definitions within the MTCR annex, and enforcing sanctions against any violating states.[11] Wortzel disagrees, arguing that without the accurate detection a robust defense system would provide, a treaty would not guarantee "no first use" states like China would falsely retaliate and initiate their own launch.[12]

b. Missile Defense Systems

The overwhelming recommendation experts make for reducing the lead China and Russia currently holds in the hypersonic arms race is to prioritize a robust defensive system. Hon. Michael Griffin, the USD R&E, testified to the United States Senate that contemporary U.S. missile defense systems hold us at a disadvantage if our adversaries were to launch hypersonic missiles into the homeland; the number one priority needs to be missile defense.[13] Dahlgren and Karako agree, and present a blueprint for how the United States needs to develop its defense in sequential order. They propose the first step is to develop a layer of exoatmospheric sensors that are capable of detecting, identifying, and tracking all missile types and then focus on the glide-phase interceptor[14] (GPI).[15] Dahlgren and Karako argue that this would bolster the United States' deterrence against China and Russia and buy enough time to shift focus to offensive strike capabilities and diplomatic policy reforms, but none of this is possible without an advanced missile defense system.[16] Terrence O'Shaughnessy and Peter Fesler also make the case for prioritizing defense,

[11] Brockmann and Stefanovich, 8–24.

[12] Wortzel, 5.

[13] *Accelerating New Technologies to Meet Emerging Threats*, Senate Committee on Armed Services (2018) (statement of Honorable Michael D. Griffin, Under Secretary of Defense for Research and Engineering).

[14] The MDA's GPI is a missile designed to intercept hypersonic weapons in the glide phase of flight. It will be compatible with the AEGIS Combat System and be employed by the MK-41 Vertical Launch System (VLS). More information on the GPI can be found in chapter four of this thesis.

[15] Dahlgren and Karako, 3.

[16] Dahlgren and Karako, 2.

especially requiring the capability of detection over all else,[17] but they take a different approach from Karako and Dahlgren. They do not believe that defense needs to be focused on in order to gain an offensive advantage because they feel that the United States already possesses the offensive advantage and America's deterrence strategy is unbalanced.[18]

c. Offensive Capabilities

None of the literature reviewed on the hypersonic arms race deemed the prioritization of hypersonic strike capabilities to be the most effective method to attaining an advantage, however, most of the readings pointed to several advantages and disadvantages that could come about. John Hyten requires U.S. Strategic Command (USSTRATCOM) to acquire a "conventional prompt global strike capability" utilizing hypersonic missiles in order to maintain the effectiveness of U.S. deterrence strategy.[19] Wortzel admits that deterrence is ineffective if there is no threat of retaliation for our adversaries and claims that the U.S. Army requires funding in order to develop an accurate hypersonic missile.[20] Weitz goes in a different direction when it comes to offensive capabilities. When referencing Russia's robust missile defense system, he theorizes that an investment in offensive hypersonic capabilities could provide leverage in achieving an arms control agreement between NATO and Russia.[21]

4. Conclusion

There seems to be little argument among the experts that the United States is significantly behind both Russia and China in regard to the hypersonic arms race. However,

---

[17] Peter Fesler and Terrence O'Shaughnessy, *Hardening the Shield: A Credible Deterrent & Capable Defense for North America* (Washington, DC: Wilson Center, 2020), 10, https://www.wilsoncenter.org/publication/hardening-shield-credible-deterrent-capable-defense-north-america.

[18] Fesler and O'Shaughnessy, 7.

[19] *Hearing on United States Strategic Command and United States Northern Command,* Senate Committee on Armed Services (2019) (statement of John E. Hyten, Commander United States Strategic Command).

[20] Wortzel, 8.

[21] Richard Weitz, *NATO's Hypersonic Challenge* (Tallinn, Estonia, International Centre for Defence and Security, 2022), 9, https://icds.ee/en/natos-hypersonic-challenge/.

the way ahead is where there are differing determinations: policy reform or investing in advanced missile defense systems. Developing hypersonic missiles is only mentioned as a secondary or tertiary at best option for the United States. Many of the experts have the three options intertwined with one another, but there is a clear distinction as to what they believe is the most important. What the existing literature does not consider is how much manpower and resources would be required to achieve all three options and if there are currently enough ways and means to make them happen.

D. POTENTIAL EXPLANATIONS AND HYPOTHESES

Arms control policy, missile defense systems, and offensive hypersonic strike capability are the three options the Unites States has to counter China and Russia in the hypersonic arms race. This thesis seeks to determine which option the United States needs to prioritize to gain a competitive advantage in the shortest time possible.

Arms control treaties or reforms to existing policy could favor the United States by ceasing the production and proliferation of hypersonic technology by its adversaries. Policy with the backing of diplomatic coercion methods, like sanctions, could disincentivize nations from continuing their pursuit of weaponizing hypersonics. Should the United States decide to take this option, it would require the support of multilateral organizations like the United Nations and NATO.

The United States' development of a robust missile defense system capable of successfully executing the entire kill chain effectively against hypersonic missiles would create multiple advantages for America. The ability to eliminate the offensive strike advantage of China and Russia would allow the United States to maintain its forward deployed units, which is an important aspect of its contemporary deterrence strategy. An increased homeland defense could also make adversaries reconsider launching its expensive hypersonic missiles at the United States if it is capable of conducting high-probability interceptions.

Prioritizing offensive hypersonic strike capabilities that compete with or surpass China and Russia would likewise improve the United States' deterrence strategy. Having the capability to conduct quick, highly maneuverable, and unpredictable strikes against

China and Russia would induce restraint when contemplating their own offensive attacks against the United States.

E. RESEARCH DESIGN

This thesis conducts a comparative analysis of the United States, Chinese, and Russian hypersonic programs. Hypersonic strike capabilities, missile defense systems, hypersonic technology budget, infrastructure, research, and strategy are all analyzed. The data collected is useful for better understanding how and why China and Russia gained an advantage in the hypersonic arms race. Trend lines are also established to serve as a blueprint for the United States to counter its adversaries. A 2019 hypersonic weapons tabletop exercise conducted by the United Nations Institute for Disarmament Research (UNIDIR) is analyzed to consider how hypersonic missiles could be used in conflict between nuclear powers.

Open-source government documents, reports, and other literature were examined throughout the research process. Differences in the capabilities and strategies between the United States, China, and Russia were analyzed to determine the cost and effectiveness of the three options available to the United States in the hypersonic arms race.

F. CHAPTER OVERVIEW

This thesis includes six chapters. Following the introduction, Chapter II examines the hypersonic strike capabilities, missile defense systems, budget, infrastructure, research, and strategy of the United States, China, and Russia. Chapters III through V analyze each U.S. option: diplomatic methods, missile defense advancements, and hypersonic weapon development. Chapter VI concludes that it will take a combination of all three options to win the hypersonic arms race; the United States needs to prioritize sharpening its sword by acquiring its own hypersonic missiles and hardening its shield by developing a robust homeland missile defense system before it can use the pen to end the arms race through legal means.

II. TALE OF THE TAPE: HYPERSONIC STRATEGY, CAPABILITIES, AND LIMITATIONS

Tale of the tape is a boxing reference used to compare the characteristics and statistics of the combatants prior to a match. This chapter will utilize open-source documents and reports to illustrate the current hypersonic strategies, capabilities, and limitations of the United States, China, and Russia. It is not intended to provide the same details that a threat brief would entail; rather, it will generally summarize the situation and confirm that the United States is clearly positioned third behind China and Russia regarding all aspects of the hypersonic arms race as well as provide recommendations on how it can close the gap between itself and its adversaries.

For each country, this chapter will examine its strategy concerning hypersonic weapons, its current hypersonic capabilities, and its research and development infrastructure that can support future hypersonic advancements. In order to assess strategy, defense budgets, official government statements, military operational concepts, and other public information will be reviewed to better understand how each state plans to employ hypersonic weapons. Current offensive and defensive hypersonic capabilities will be highlighted, as well as future projects that have been announced. Lastly, the frequency of hypersonic testing; number of research and development facilities; and collaboration between academic and military research organizations will be analyzed to determine the current state of each country's hypersonic infrastructure.

A. THE UNITED STATES

The United States finds itself positioned third behind China and Russia in the hypersonic arms race. This section will explain why this is the case, looking first at U.S. strategy concerning hypersonic weapons; its current offensive and defensive capabilities; and its infrastructure. Its current hypersonic strategy fails to identify the ways and means to solve the hypersonic problem as well as lacking a timeline for when new hypersonic technologies can be expected. Currently, the United States has no offensive hypersonic strike capabilities, and fields missile defense systems that are not designed to defeat

hypersonic threats against the homeland. There are, however, current developments for hypersonic missiles, new missile defense systems, and interceptors across multiple government organizations. Hypersonic missiles are expected to be completed until 2023 and to be loaded into a surface combatant in 2025. An upgraded missile defense system, including space-based sensors, and an effective interceptor are expected to be completed in the middle of the decade at the earliest. Additionally, hypersonic infrastructure needs improvements and the United States' testing of hypersonic capabilities is significantly less than its adversaries.

1. Strategy

The United States' strategy for the hypersonic arms race is vague and ambiguous. The newest version of the DOD's National Defense Strategy acknowledges the importance of developing hypersonic weapons and defense but lacks timelines and phases detailing when the DOD can expect to field them. Additionally, the fiscal year 2023 defense budget shows a misleading disproportionate amount of funds allocated between programs; there are debates among leadership on whether to prioritize offensive or defensive systems; and there is a lack of programs of record for hypersonics that makes it difficult to determine how the United States is going to answer China and Russia. Though it is difficult to determine our nation's full hypersonic strategy in an unclassified thesis, the open-source reports and documents cited are more than enough to reveal an indistinct and ambivalent strategy.

The DOD's 2022 National Defense Strategy (NDS) included the first Missile Defense Review (MDR) since 2019. The strategic document acknowledges hypersonic weapons as destabilizing to military strategy, describes them as an emerging threat to U.S. national security interests, and argues that the current hypersonic missiles fielded by China and Russia are designed specifically to defeat contemporary missile defense systems.[22] To counter this, the document states that the United States must "continue to develop active

[22] Department of Defense, *2022 National Security Strategy of the United States of America* (Washington, DC: Department of Defense, 2022), 1–6, https://www.defense.gov/National-Defense-Strategy/.

and passive defenses…pursue a persistent and resilient sensor network…improve attribution…enable engagement…[and] pursue joint research and development on hypersonic defense programs."[23] Despite the long list of requirements listed for a robust missile defense system, there is no indication as to when the United States can expect to field components of the system. Offensively, the National Defense Strategy views hypersonic strike capability as a potential function for deterrence by denial strategy but sees it as a "mid- to long-term" project.[24] It also determines hypersonic missiles as a counter to adversarial anti-access/area denial (A2/AD) threats.[25] The NDS/MDR does an excellent job at highlighting the direction the United States intends to go involving hypersonics; however, the lack of timelines and milestones to achieve its desired end state makes this strategy defective.

In addition to the NDS, the DOD's monetary priorities seem to favor missile defense. The fiscal year 2023 budget request reveals that of the $773 billion requested, $24.7 billion is earmarked for missile defeat and defense capabilities, $4.7 billion for the development of offensive hypersonic strike capabilities, and $1.26 billion to enhance hypersonic research and testing sites.[26] In other words, of the $30.66 billion requested for all things hypersonic, 80.56% is being requested for defensive systems, 15.33% for missile capability, and 4.11% for infrastructure. However, using these budget request numbers solely to determine which strategy the United States prefers would be misleading; defensive capabilities are becoming more difficult and expensive to field than offensive ones as weapon technology advances.[27] It is also unclear how much money would be required to create a system capable of deterring an adversarial hypersonic attack, as well

[23] Department of Defense, 7.

[24] Department of Defense, 8.

[25] Department of Defense, 9.

[26] Office of the Under Secretary of Defense Chief Financial Officer, *Defense Budget Overview: United States Department of Defense Fiscal Year 2023 Budget Request,* 3–364B8D0 (Washington, DC: OSD).

[27] John Dolan, Richard Gallagher and Richard Mann, *Hypersonic Weapons – A Threat to National Security* (Palo Alto, CA: RealClear Defense, 2019), https://www.realcleardefense.com/articles/2019/04/23/hypersonic_weapons__a_tthrea_to_national_security_114358.html.

as produce the amount of offense capabilities that matches China and Russia. It is possible that the funds requested is to achieve both goals.

Key decision-makers for the United States' hypersonic strategy have publicly disagreed on which direction the nation should go towards. In January 2022, Defense Secretary Lloyd Austin requested the presence of all major defense company CEOs to express how far behind the United States is in relation to China and Russia in the hypersonic arms race and his desire to field a hypersonic strike capability as soon as possible.[28] The Office for the Under Secretary of Defense for Research and Engineering (OUSD[R&E]) Program Director of Hypersonics, Michael White, echoed this offensive prioritization by confirming that due to the complexity of fielding an effective defensive system, offense will need to be prioritized first.[29]

White's boss, Undersecretary of Defense for Research and Engineering Heidi Shyu, has recently downplayed the need for hypersonic missile production. Shyu states that the United States has a portfolio approach: hypersonic missiles are only one of fourteen critical areas of OUSD(R&E) and all of them have proportionate value.[30] U.S. Air Force Secretary Frank Kendall agrees with Shyu, stating that hypersonic missiles are not "a magic solution to our problems…We're not trying to keep up with the Chinese and mirror image what they're doing. We're trying to do what we need for our objectives militarily."[31] This approach towards the hypersonic arms race that Shyu and Kendall display was directly responded to by the ranking member of the House Armed Services Committee's (HASC) strategic forces panel Representative Doug Lamborn who claims that hypersonic weapons

[28] Patrick Turner and Marcus Weisgerber, SecDef Austin Summons Hypersonics CEOs (Washington, DC: Defense One, 2022), https://www.defenseone.com/technology/2022/01/secdef-austin-summons-hypersonics-ceos/361229/.

[29] Dolan, Gallagher and Mann, 2.

[30] Heidi Shyu, "Under Secretary of Defense for Research and Engineering Heidi Shyu Remarks at The Hill Virtual Event on 'National Security at the Speed of Sound: Hypersonics in American Defense'" (Interview, The Hill, October 18, 2022), https://www.defense.gov/News/Transcripts/Transcript/Article/3192611/under-secretary-of-defense-for-research-and-engineering-heidi-shyu-remarks-at-t/.

[31] Frank Wolfe, "Shyu Says Hypersonic Weapons Just One 'Arrow' in DOD Quiver, While Rep. Lamborn Argues for Parity*," Defense Daily*, October 18, 2022, https://www.defensedaily.com/shyu-says-hypersonic-weapons-just-one-arrow-in-dod-quiver-while-rep-lamborn-argues-for-parity/advanced-transformational-technology/.

and achieving equal status with China in the hypersonic arms race should be the nation's top priority.[32]

The statements made by multiple leaders across multiple government organization—including contradictory comments within the same organization—regarding where the nation's priority in hypersonic technology stands makes it difficult to determine exactly how the United States will proceed in the hypersonic arms race.

Since 2000, the United States has sought to utilize hypersonic glide vehicles and hypersonic cruise missiles to resolve regional conflicts through its conventional prompt strike (CPS) program.[33] CPS is intended to utilize long range precision strikes against critical targets without relying on forward deployed troops and bases around the world.[34] As the name of the program implies, the United States only wants to employ conventional hypersonic missiles vice nuclear-capable ones; CPS is not meant to supplement or substitute current U.S. nuclear capabilities.[35] It can be determined that the United States deems its first- and second-strike capability that its contemporary nuclear triad provides is sufficient for maintaining hegemony in nuclear deterrence worldwide. Currently, there is not a specific designation for how hypersonic missiles would be used by the United States other than that it can become an asset for the long-established CPS program. The Department of Defense has yet to commit to the development of hypersonic missiles—current production is for evaluation purposes only—as well as not creating any programs of record and mission requirements.[36] Without a program of record, hypersonic missile development efforts do not receive direct funding from the government and must rely on any leftover dollars from systems with programs of record. Until the DOD establishes a

[32] Wolfe.

[33] Kelley Sayler, *Hypersonic Weapons: Background and Issues for Congress*, CRS Report No. R45811 (Washington, DC: Congressional Research Service, 2022), 1, https://crsreports.congress.gov/product/details?prodcode=R45811.

[34] Amy Woolf, *Conventional Prompt Global Strike and Long-Range Ballistic Missiles: Background and Issues*, CRS Report No. R4164 (Washington, DB: Congressional Research Service, 2021), 1, https://crsreports.congress.gov/product/details?prodcode=R45811.

[35] Woolf, 1.

[36] Sayler, 1.

commitment and strategy for the employment of hypersonic missiles, the time-consuming process of developing platform and combat system interoperability and integration will not be feasible.

The United States is seemingly in a state where it wants the best of both worlds: it wants hypersonic strike capabilities designed to defeat adversary A2/AD systems and desires a comprehensive missile defense system that can track and defeat hypersonic missiles effectively. The previously cited open-source documents, the United States' historical military philosophy of keeping the fight as far from the homeland as possible,[37] and the emerging A2/AD capabilities China and Russia fields create a conundrum for U.S. hypersonic strategy. The United States wants to operate forward deployed units within adversarial A2/AD zones yet wants to invest in CPS capabilities to reduce the amount of forward deployed units all while leaping ahead Russia and China in offensive and defensive hypersonic systems.

2. Capabilities and Limitations

The United States is reportedly having a difficult time developing offensive and defensive capabilities compared to its adversaries.[38] It appears that Washington—either due to other priorities, lack of funding, or a combination of the two—has been content to focus its efforts on other military advancements over hypersonic missile technology, until recently.

a. Offense

Offensively, the United States does not field any operational hypersonic missiles. All the hypersonic missiles being manufactured today are strictly for research and testing purposes. Its current offensive developments of public record include the Navy's Conventional Prompt Strike Weapon System and Hypersonic Air-Launched OASuW (HALO); the Army's Long-Range Hypersonic Weapon (LRHW); the Air Force's Air-

[37] Fesler and O'Shaughnessy, Hardening the Shield: A Credible Deterrent & Capable Defense for North America, 6.

[38] Wortzel, Hypersonic Weapons Development in China, Russia and the United States: Implications for American Security Policy, 4.

Launched Rapid Response Weapon (ARRW) and Hypersonic Attack Cruise Missile (HACM); and DARPA's Tactical Boost Glide, Operational Fires, and Hypersonic Air-Breathing Weapon Concept follow-on (MoHAWC).[39] Regardless of the numerous on-going projects across multiple organizations, it will be at a minimum the end of 2023 until at least one of these projects are ready to be effectively employed by the United States.[40]

It should also be noted that all of these projects have been determined to be conventional, not nuclear. The idea of only fielding conventional hypersonic warheads increases both the importance of missile accuracy and the production processes required to achieve accuracy, creating longer timelines when compared to hypersonic missiles designed to be equipped with a nuclear warhead. Additionally, each missile will need to be successfully integrated with multiple platforms and combat systems to determine if it can be employed.

It has yet to be made clear which platforms are being targeted as the desired delivery vehicles for hypersonic missiles; however, the U.S. Navy is modifying its three Zumwalt-class destroyers with four 87-inch missile tubes with the intent of launching hypersonic missiles in 2025 and its Virginia-class submarines in 2029.[41] Testing is expensive, and without a program of record, it will be difficult for the United States to afford platform-specific hypersonic strikes when the missiles are ready for employment.

b. Defense

The same that is true about offensive capabilities is the same about defensive capabilities. The United States' missile defense architecture on both land and in space is ineffective against hypersonic missile threats. Radar horizon limitations of most earth-based radars results in only having a chance at detection in the terminal-phase of flight,

39 "Intermediate Range Conventional Prompt Strike Weapon System," Global Security, accessed January 29, 2023, https://www.globalsecurity.org/wmd/systems/cps.htm; Sayler, 5.

40 Sayler, 1.

41 Sam LaGrone, "Navy Details Hypersonic Missile Plan for Zumwalt Destroyers, Virginia Submarines," *USNI News*, November 3, 2022, https://news.usni.org/2022/11/03/navy-details-hypersonic-missiles-on-zumwalt-destroyers-virginia-submarines.

leaving decision-makers minimal time to react.[42] United States Northern Command (USNORTHCOM) and North American Aerospace Defense Command (NORAD)—the commands primarily responsible for defending North America against adversarial strikes—currently field defense systems that were designed to counter intercontinental ballistic missiles (ICBMs) and are not integrated with one another.[43]

General Glen Vanherck, Commander of NORTHCOM and NORAD, admitted to the Senate Armed Forces Committee that there is no way for the United States to defend against a hypersonic missile attack.[44] These outdated and stove-piped systems creates a delay in sharing detection and tracking information and would be at a disadvantage against Chinese and Russian hypersonic missiles if they decided to employ them against the homeland today.[45] According to Masao Dahlgren and Tom Karako, the United States would require "an integrated, layered, system-of-systems approach, new sensing and interceptor capabilities, different operational concepts, doctrinal and organizational changes, and modified policy expectations" in order to field an effective defense capability.[46]

These requirements listed by Dahlgren and Karako are currently in development by both the Space Development Agency (SDA) and Missile Defense Agency (MDA). The SDA is working on the Proliferated Warfighter Space Architecture (PWSA), a constellation of 550 satellites designed to "unify and integrate next generation capabilities across [DOD] and industry."[47] The PWSA's seven layers will include wide field of view

---

[42] Kelley Sayler, *Hypersonic Missile Defense: Issues for Congress*, CRS Report No. IF11623 (Washington, DC: Congressional Research Service, 2023), 1, https://crsreports.congress.gov/product/details?prodcode=IF11623.

[43] Fesler and O'Shaughnessy, 8.

[44] Statement of General Glen D. Vanherck, United States Air Force Commander United States Northern Command and North American Aerospace Defense Command, Senate Committee on Armed Services (2022) (statement of Glen D. Vanherck, Commander United States Northern Command and North American Aerospace Defense Command).

[45] Statement of Honorable Michael D. Griffin, 14.

[46] Masao Dahlgren and Tom Karako, *Complex Air Defense: Countering the Hypersonic Missile Threat* (Lanham, MD: CSIS, 2022), 1, https://www.csis.org/analysis/complex-air-defense-countering-hypersonic-missile-threat.

[47] Sayler, 1.

(WFOV) satellites that provide global coverage and tracking of hypersonic missiles and the MDA's Hypersonic and Ballistic Tracking Space Sensor (HBTSS) which provides more sensitive coverage required to achieve target quality data for intercepting platforms.[48] There is no solidified date for when the PWSA will be fully operational, but former Under Secretary of Defense for Research and Engineering, Dr. Michael Griffin, has gone on record in saying that it would not be until at least 2025 before the United States obtains a viable defense against hypersonic missiles.[49]

The MDA is seeking ways to defeat hypersonic missiles in flight both kinetically and non-kinetically. One of its current projects is the Glide-Phase Interceptor (GPI): an intercepting missile designed to integrate with the AEGIS Weapon System and defeat hypersonic missiles before the terminal phase.[50] This would allow for current U.S. Navy warships conducting ballistic missile defense (BMD) missions the ability to intercept all potential long-range strike capabilities from its adversaries. GPI has been contracted to Lockheed Martin, Northrop Grumman, and Raytheon and is projected to be completed by the middle of this decade.[51]

The United States has identified that it cannot efficiently defend itself from hypersonic missiles, but through the continued development of PWSA and GPI, it should be capable of tracking and intercepting hypersonic missiles within the next three years.

c. Infrastructure

The United States' hypersonic research and testing facilities currently lack the requisite resources to make significant progress in the hypersonic arms race. A study conducted by the Institute for Defense Analyses (IDA) in 2014 found that there are 48 test facilities, comprised of DOD, NASA, DOE, private, and academic university owned

---

[48] Sayler, 1–2.

[49] Michael Griffin, "Media Availability With Deputy Secretary Shanahan and Under Secretary of Defense Griffin at NDIA Hypersonics Senior Executive Series" (Interview, December 13, 2018), https://www.defense.gov/News/Transcripts/Transcript/Article/1713396/mmedi-availability-with-deputy-secretary-shanahan-and-under-secretary-of-defens/.

[50] Sayler, 2.

[51] Sayler, 2.

facilities, dedicated to the development of hypersonic technologies.[52] Wind tunnels are used within these facilities to simulate the speed, flow, and stress of hypersonic flight on materials in order to gather data required for development. Of all the testing facilities in the United States, none of them have the capability to simulate all aspects of hypersonic flight; this can only be accomplished through actual flight tests.[53] Despite the number of instruments and research centers dedicated to hypersonics, the United States is not testing nearly as much when compared to its adversaries. Vice Chairman of the Joint Chiefs of Staff, General John Hyten went on record saying that China has conducted hundreds of hypersonic weapon tests compared to the United States' nine in the past five years.[54] The material condition of these research and testing sites are below standards. A two-year-long assessment of all hypersonic testing facilities to determine if the United States can meet production milestones was conducted by the DOD's Office of Inspector General concluded in February 2022, but the evaluation was not made available to the public. However, within that two-year evaluation, Congress tasked the Secretary of Defense to come up with a plan on improving its contemporary research and development facilities.[55] It can be concluded that the current state of the United States' hypersonic testing sites is not at the standard required to accomplish the goals outlined in its national defense strategy.

B. CHINA

PRC leadership seems to be fully aligned when it comes to the hypersonic arms race. Its strategy for hypersonics both answers the perceived threat of the United States CPS program and seeks disruptive technologies that can defeat regional and national missile defense systems. China already fields an HGV which is deployed with its medium-range ballistic missiles and potentially intercontinental-range ballistic missiles. The PLA is also making strides to being able to launch hypersonic strikes with multiple platforms

[52] Sayler, Hypersonic Weapons: Background and Issues for Congress, 12.

[53] Knox Millsaps, "Hypersonics Overview Office of Naval Research: Strategy and Discussion Group" Presentation at Washington, DC, October 26, 2022.

[54] Colin Clark, "'Hundreds' of China Hypersonic Tests Vs. 9 US; Hyten Says U.S. Moves Too Slowly," *Breaking Defense,* October 28, 2021, https://breakingdefense.com/2021/10/hundreds-of-china-hypersonic-tests-vs-9-us-hyten-says-us-moves-too-slowly/.

[55] Sayler, 13.

across multiple domains. While China is currently vulnerable to hypersonic weapon attacks, it is researching and developing an advanced missile defense system. Its infrastructure allows it to test and develop hypersonic capabilities at a much faster pace than any other country.

1. Strategy

China has two primary driving factors for its hypersonic strategy: a response to the challenges the United States' CPS program presents to the PRC and to exploit the difficult-to-defend attributes of hypersonic strikes in order to achieve its warfare operational concepts. Additionally, the pursuit of hypersonics aligns with China's grand strategy of military modernization and pursuit of global hegemony. It is also yet to be determined if the PLA plans to use hypersonic missiles in a strictly conventional manner or arm some of them with nuclear warheads.[56]

The United States' announcement of CPS—its desire to conduct conventional long-range strikes on its adversaries at any given time—created a security dilemma for the PRC. Its vulnerability to a United States first strike is perceived by the Chinese as a destabilizing posture and a direct threat to its small nuclear armament, chemical weapons, biological weapons, and critical infrastructure which would promise the United States a large strategic advantage if destroyed.[57] This would eliminate China's second-strike capability in a scenario where nuclear warheads could be used. CPS also causes disruption to China's priority to maintain "mutual vulnerability"[58] with the United States and other nuclear powers. In other words, China's understanding of its nuclear disparity compared to the United States means it needs to develop other capabilities in order to act as a deterrence. The capability required to achieve mutual vulnerability and counter CPS is agreed upon by

---

[56] Richard Weitz, "China's Hypersonic Missiles: Methods and Motives," *China Brief* vol 21, no. 15 (July 2021): 27.

[57] Tong Zhao, "Conventional Challenges to Strategic Stability: Chinese Perceptions of Hypersonic Technology and the Security Dilemma," *Carnegie Endowment for International Peace*, July 23, 2018, 2, https://carnegieendowment.org/2018/07/23/conventional-challenges-to-strategic-stability-chinese-perceptions-of-hypersonic-technology-and-security-dilemma-pub-76894; Zhao, 18; Lora Saalman, China's Calculus on Hypersonic Glide," *Stockholm International Peace Research Institute*, August 15, 2017, 2, https://www.sipri.org/commentary/topical-backgrounder/2017/chinas-calculus-hypersonic-glide.

[58] Zhao, 1.

most Chinese military experts to be hypersonic technology.[59] China sees hypersonic technology as its answer to the security dilemma CPS presents as well as to maintain mutual vulnerability with the United States.

Hypersonic capabilities are in near perfect alignment with the PLA's current doctrine that dictates how it will fight and win wars. A RAND report on China's operational concepts in wartime lists some of the PLA's main goals as controlling wars via network warfare and target centric warfare (TCW).[60] These concepts can help confirm how the PLA plans to utilize hypersonics during conflict. Network warfare involves paralyzing the enemy's decision-making, command and control (C2), sensors, and other systems that conduct the adversary's operations by both kinetic and non-kinetic means.[61] The kinetic aspect of this type of warfare is where hypersonic missiles would play a key function in eroding adversarial decision-making capabilities. According to the RAND report, the PLA will require accurate long-range strikes to achieve this operational advantage.[62] TCW is like network warfare but has more emphasis on physical operational systems like platforms and facilities. PLA documents call for the ability to locate the enemy's vulnerabilities and attack them with "speed, precision, and intensity…leaving the enemy no room and no time to adjust and adapt."[63] The long-range accuracy, high-speed, unpredictable flight patterns, and nuclear-capable attributes of hypersonic missiles make it a weapon system capable of conducting network and target centric warfare in an efficient manner. For example, it is projected that the PLA would use hypersonic weapons as a first strike against the United States, specifically to degrade its air and missile defense systems, and then conduct follow-on strikes with more catastrophic non-hypersonic weapons.[64]

[59] Zhao, 16.

[60] Edmund Burke et al., *People's Liberation Army Operational Concepts*, RR-A394-1 (Santa Monica, CA: RAND Corporation, 2020), 9, https://www.rand.org/pubs/research_reports/RRA394-1.html.

[61] Burke et al., 10.

[62] Burke et al., 12.

[63] Burke et al., 15–16.

[64] Weitz, 27.

Though the PLA views hypersonics as an answer to creating mutual deterrence with the United States, it intends to utilize them differently than nuclear weapons. Since World War II, nuclear weapons have been used strictly as a deterrence strategy. This is not how China will approach its hypersonic arsenal. The PLA views its hypersonic missiles, which are nuclear capable, through a utilitarian scope; it wants to use them in all theaters of operations.[65] Additionally, China understands the advantage hypersonics has against contemporary missile defense systems and will use them against both theater and national missile defense systems, which is made apparent by its exploration of attaching HGVs to its medium- and intercontinental-range ballistic missiles.[66]

In terms of grand strategy, President Xi Jinping's call for a total military force modernization by 2035 with the ability to win wars in all theaters of operations by 2050 illustrates why China has pursued emerging technologies like hypersonics.[67] China identifying hypersonics as a disrupting technology and pursuing the development of them also plays into their military policy of avoiding technological surprises.[68] Rather, in order to meet its goals of achieving military superiority globally, the PLA must be constantly seeking disruptive emerging technologies makes progress towards establishing itself as the world power.

2. Capabilities and Limitations

The following subsections explore the current hypersonic strike capabilities, missile defense systems, and supporting infrastructure of the PRC.

a. Offense

Offensively, the PLA already fields a hypersonic strike capability within its military force. U.S. intelligence entities assess that China's medium-range ballistic missile, the DF-

65 Saalman, 4.

66 Zhao, 5; Saalman, 4.

67 Burke et al., 1.

68 Zhao, 14.

17, can launch its DF-ZF HGV at a range of 1,243 miles and is operational for PLA use.[69] The DF-17 is a dual use weapon system—it can be either conventional or nuclear—and was developed specifically to target adversary platforms and bases within the Western Pacific, according to a PRC military expert.[70] China is also developing the capability of conducting hypersonic strikes against the U.S. mainland. Multiple tests have been conducted by the PRC on pairing the DF-41 ICBM with the DF-ZF, giving China the ability to deploy conventional and nuclear HGVs without any range restrictions.[71] New advancements and innovative uses for hypersonic strikes are also being explored by China. In 2020, China's Institute of Mechanics successfully ran a scramjet engine for 10 minutes, which would allow for sustained hypersonic flight for nearly 2,500 miles.[72] This would nearly double the current range of the highly maneuverable DF-ZF HGV and leave Guam within range of a coastal hypersonic strike if applied successfully. The PLA is also exploring hypersonic strike capabilities in the subsurface and space domains, with the possibility of the PLA Navy adding nuclear-armed HGVs to its JL-2 SLBMs and U.S. Air Force Secretary Frank Kendall citing that China can potentially strike its adversaries from space.[73] It is evident that the PRC plans to use hypersonic missiles across multiple domains to defeat both regional and national missile defenses.

b. Defense

Defensively, China currently lacks an advanced missile defense system capable of defeating hypersonic missiles. The PLA's primary missile defense capabilities utilizes the HQ-9 long-range surface-to-air missile system and warship combat systems to defend its

---

[69] Sayler, Hypersonic Weapons: Background and Issues for Congress, 17; Weitz, 25.

[70] Department of Defense, *Military and Security Developments Involving the People's Republic of China 2021* (Washington, DC: Department of Defense, 2021), 61, https://media.defense.gov/2021/Nov/03/2002885874/-1/-1/0/2021-CMPR-FINAL.PDF.

[71] Sayler, 17; Weitz, 25.

[72] Weitz, 26–27.

[73] Weitz, 26; Greg Hadley, "Kendall: China Has Potential to Strike Earth From Space," *Air & Space Force Magazine*, September 20, 2021, 2, https://www.airandspaceforces.com/global-strikes-space-china-frank-kendall/.

homeland, but both were designed for the ballistic missile threat.[74] These systems do not allow China the ability to provide early warning or track a hypersonic attack efficiently.[75] A kinetic mid-course interceptor, to include a space-based architecture, has been tested as recently as February 4, 2021.[76] Like the United States, the PRC has acknowledged its vulnerabilities and is making strides towards bolstering their defenses.

c. Infrastructure

China's robust hypersonic infrastructure is a primary reason why it leads the United States in the hypersonic arms race. China currently fields 23 wind tunnels across multiple governmental and academic facilities, allowing it the capability of testing hypersonics up to Mach 15.[77] Other near-term developments include another wind tunnel to be completed in 2022 that can reach Mach 30 and a large-scale supercomputer program designed for advanced simulations, modeling, and development of hypersonics.[78] The PRC's infrastructure was viewed as so impressive to the Washington director of the Ronald Reagan Presidential Foundation and Institute and appointed commissioner of the U.S. National Defense Strategy, Dr. Roger Zakheim, that he claimed in 2019 that, " China…both in terms of the programs they have, the planned test and their industrial capabilities and where their investments are to test [hypersonics]…they're first with no real clear second."[79] China's hypersonic infrastructure advantage will continue allow it to widen the gap with the rest of the world in developing and testing hypersonic technology.

---

[74] Department of Defense, 80.

[75] Zhao, 6.

[76] Department of Defense, 57.

[77] Sayler, 18.

[78] Sayler, 18; Weitz, 26.

[79] "China's Hypersonic Missile Advances and U.S. Defense Responses," March 11, 2019, posted by Hudson Institute, video, 58:42, https://www.hudson.org/events/1662-china-s-hypersonic-missile-advances-and-u-s-defense-responses32019.

C. RUSSIA

The Russian Federation's stance on hypersonic weapons is that they are a necessity to counter the U.S. threat. This fosters a strategy that intends to utilize hypersonics in a way that blends with its current military doctrine. President Vladimir Putin said that his nation's nuclear deterrence strategy would become ineffective due to the United States' decision to withdraw from the ABM Treaty in 2002, and the advancing U.S. missile defense systems that would leave Russia at a disadvantage due to the 2010 New START Treaty. This foresight led to Russia being the first country to field a hypersonic strike capability with unlimited range as well as developing a missile defense system that can intercept hypersonic missiles.

1. Strategy

The Russian Federation's strategy seems to be aligned with why hypersonic technology would be advantageous to it as well as deploying them in a way that bolsters its fighting forces. Russia justifies its pursuit of hypersonic technology as a necessity to answer the United States' military technological advances and has found that the characteristics of hypersonics conform with the way it wants to fight and win wars.

Russian President Vladimir Putin has made it clear to the rest of the world that his country now fields hypersonic systems due to the actions of the United States. In his 2018 Presidential address to the Federal Assembly, Putin explained that Russia's development of hypersonics is due to the United States withdrawing from the Anti-Ballistic Missile Treaty in 2002 and the forward deployment of its advanced missile defense systems beyond its borders.[80] President Putin claims that the advancement of U.S. missile defense systems, like the Ground-Based Missile Defense System (GMD) and the European Phased Adaptive Approach (EPAA), devalues the New START treaty signed by both countries in 2010.[81] The New START treaty reduces and limits the number of nuclear weapons for both parties, which means one side only needs to manufacture enough interceptors and develop a robust

[80] Vladimir Putin, *Presidential Address to the Federal Assembly* (Saint Petersburg, Russia: March 1, 2018), en.kremlin.ru/events/president/news/56957.

[81] Putin.

missile defense system to overcome the other side's nuclear threat. He views hypersonic missiles as the answer to defeating the United States' global missile defense systems and maintaining its nuclear deterrence strategy.[82]

Understanding Russian military doctrine and operational concepts reveals how exactly hypersonic missiles would be used on the battlefield. Russia's theory of victory is achieving territorial conquest by prioritizing a numbers advantage for their boots on the ground, continuous kinetic attack capabilities, and the total physical elimination of its enemy.[83] The means to obtaining victory come from concentrating its power and executing continuous strikes from the air, land, and sea.[84] Additionally, it attempts to obtain the psychological advantage against its enemy by targeting civilian populations and infrastructure with as much widespread damages as possible.[85] As warfare evolves with the introduction of emerging technologies, Russia is content with sticking with its decades-old military strategy and uses technological advances as supplementation to its contemporary doctrine.[86]

Taking what has just been explained about how Russia fights and comparing it to the characteristics of what its current hypersonic arsenal—which will be detailed further in the next section—shows exactly how Russia intends on using them. First, it is obvious that a hypersonic strike is kinetic in nature. Second, hypersonic missiles can be mass-produced and launched continuously from all domains to achieve an overwhelming attack on an enemy. Russia has developed the capability to launch hypersonic missiles from its land-based ICBMs, warships, submarines, and air assets.[87] Lastly, hypersonic payloads can be nuclear, which would cause maximum damage against its target and the surrounding area.

---

[82] Putin.

[83] Nicolo Fasola, *How Russia Fights*, No. 12 (Rome, Italy: NATO Defense College Research Division, 2022), 1–2, https://www.ndc.nato.int/about/organization.php?icode=168.

[84] Fasola, 4.

[85] Fasola, 3.

[86] Fasola, 2.

[87] John Borrie, Amy Dowler and Pavel Podvig, *Hypersonic Weapons: A Challenge and Opportunity for Strategic Arms Control* (The United Nations Office for Disarmament Affairs, New York: The United Nations Publication, 2019), 10, https://www.un.org/disarmament/publications/more/hypersonic-weapons-a-challenge-and-opportunity-for-strategic-arms-control/.; Sayler, 14.; Fasola, 118.

Putin has confirmed that Russia will utilize nuclear warheads on its hypersonic platforms.[88] Hypersonic missiles check all the boxes to Russia's military objectives and statements made by its President and recent hypersonic developments detail how they will be employed in times of conflict.

2. Capabilities and Limitations

The following subsections explore the current hypersonic strike capabilities, missile defense systems, and supporting infrastructure of the Russian Federation.

a. Offense

Russia has hypersonic strike capabilities available for use by land-, air-, surface, and sub-surface platforms. The Avangard, also known as the Yu-71, is a nuclear-capable HGV that has been operational since 2019.[89] This advanced missile can reach Mach 20, has a range of 10,000 km, and utilizes AI to calculate its flight path prior to launch.[90] The Avangard is deployed via the SS-19 Stiletto ICBM and potentially Russia's newest ICBM, the RS-28 Sarmat.[91] Pairing the long-range Avangard with its ICBMs gives Russia the ability to conduct a hypersonic attack anywhere in the world. Another hypersonic weapon in development, the Tsirkon, is a HCM that can reach speeds between Mach 6 and Mach 8 and has an approximate range of 625 miles.[92] The Tsirkon is designed to strike both land and sea based targets, and has already been successfully tested on Kirov-class cruisers, Steregushchiy-class corvettes, Admiral Gorshkov-class frigates, and Yasen-class submarines with the intent to be fully operational on the Admiral Gorshkov-class frigates

[88] Putin.

[89] Dmitry Stefanovich, "Hypersonic Weapons and Arms Control," *Russian International Affairs Council*, April 6, 2020, 2, https://russiancouncil.ru/en/analytics-and-comments/analytics/hypersonic-weapons-and-arms-control/; Sayler, 14.

[90] Samuel Bendett et al., *Artificial Intelligence and Autonomy in Russia*, DRM-2021-U-029303 (Arlington, VA: CNA, 2021), 91, https://www.cna.org/our-media/newsletters/ai-and-autonomy-in-russia; Borrie, Dowler and Podvig, 10–11.

[91] Borrie Dowler and Podvig, 10–11; Sayler, 14.

[92] Sayler, 15.

by the end of 2022.[93] Additionally, Russia has developed the capability to launch hypersonic missiles from its S-70 Okhotnik drone, which is designed to serve as an unmanned wingman to the Su-57 fifth-generation fighter.[94] The Russian military has achieved the ability to launch nuclear hypersonic strikes from multiple domains across multiple platforms.

b. Defense

Defensively, Russia relies on both legacy and new methods of missile defense to potentially counter a hypersonic missile strike against its assets. Russia's integrated air defense system (IADS) and other standalone BMD platforms make up most of its missile defense architecture.[95] Moscow still relies on the wide area ability of nuclear-armed interceptors, something no longer used by anybody else, to defend against strikes.[96] However, it also fields a newer capability, the S-500 missile defense system, which is reportedly capable of intercepting hypersonic missiles at a 600 km range.[97] Out of the three main competitors in the hypersonic arms race, Russia's missile defense system is the only one that has a component designed and fielded specifically for the hypersonic threat.

c. Infrastructure

There is not a lot of open-source documentation on the hypersonic infrastructure of Russia. What is known is that hypersonics are tested and developed within multiple educational and military facilities like the Central Aero-Hydrodynamic Institute, the Institute of Theoretical and Applied Mechanics, and Dombarovkiy Air Base.[98] Though information is scarce, the fielding of both offensive and defensive capabilities implies that there is a robust hypersonic infrastructure in place.

---

[93] Sayler, 15.

[94] Bendett et al., 118.

[95] Bendett et al., 104.

[96] Dahlgren and Karako, *Complex Air Defense,* 35.

[97] Bendett et al., 149–150.

[98] Sayler, 16.

D. CONCLUSION

The United States is in third place behind both China and Russia in the hypersonic arms race. Its strategy is unclear as to how exactly it plans to answer the hypersonic threat going forward, it has no hypersonic strike capabilities that are currently operational, and it has no capability of defending a hypersonic attack against its homeland. In contrast, its adversaries are fully aligned with the importance of hypersonic capabilities and how they want to utilize them within their militaries. Both China and Russia have successfully fielded HGVs that can be deployed by their ICBMs, giving them intercontinental range. Russia has developed the ability to intercept hypersonic missiles, albeit only at a short range when compared to the distance at which ballistic missiles are typically intercepted, but this is a system that can be built upon. China's infrastructure holds the clear advantage over those of the United States and Russia, but a lack of information regarding Russian infrastructure makes it difficult to assess its exact position.

There are three areas of focus the United States needs to consider if it wants to leap ahead both China and Russia: diplomatic measures, the acquisition of a hypersonic arsenal, and the development of a missile defense system designed to counter hypersonic weapons. The following chapters will explore these areas individually, weigh the pros and cons of each, and make a recommendation on how the United States can win the hypersonic arms race by solely prioritizing that area of focus.

III. THE PEN: ENDING THE HYPERSONIC ARMS RACE WITH DIPLOMACY

This chapter argues how diplomatic actions can end the hypersonic arms race for the United States. It explores the multiple variables within arms control agreements, theories, and current measures already implemented to determine the most efficient way the United States can proceed without prioritizing offense and/or defense.

The first section of this chapter will determine if it is worth the United States' time to even pursue arms control measures, what types are available, and the many variables to consider when constructing an arms control proposal. The second section analyzes contemporary arms control agreements and organizations that are potentially a few modifications away from assisting the United States toward ending the hypersonic arms race. The concluding section synthesizes the information from the first two sections and recommends how the United States should proceed if it chooses to prioritize diplomacy. The analysis ultimately determines that a trilateral, legally binding agreement utilizing asymmetry of domains and minimal warhead deterrence clauses is the best chance at three major powers coming to an agreement.

A. ARMS CONTROL

Arms control measures and agreements are an option for the United States to potentially end the hypersonic arms race without expending large amounts of resources that acquiring hypersonic weapons or developing a robust missile defense system specifically for hypersonic missiles would require. Before it can commit to diplomatic action; however, it first needs to figure out if pursuing arms control is the best option available by assessing both domestic and international perspectives. Secondly, it needs to determine how it can develop a robust proposal that is most likely to receive both China and Russia's concurrence. The United States will need to sift through many instruments within arms control measures and agreements—like type, objectives, areas of focus, and concessions—to determine the best combination that has promotes the highest probability of approval by all participants Finally, the U.S. government needs to weigh the challenges

and effects to confirm the original decision of exploring arms control options for ending the hypersonic arms race.

1. Should the United States Pursue Arms Control?

In order to determine if arms control is the best option for the United States to end the hypersonic arms race, a comprehensive internal and external assessment is required. Internally, the United States needs to determine if adversaries that have hypersonic weapons present enough of a threat to its national security to cause concern and if the balance of power is beginning to shift away from it. Externally, the United States must be able to forecast global repercussions if it does not pursue arms control for hypersonic weapons.

The first question the United States needs to answer prior to deciding arms control exploration is simple: would China and Russia acquiring hypersonic weapons give them a military advantage over the United States, and will it alter the global balance of power? In order to stabilize a potential arms race, a state will choose to acquire new emerging military technologies for three reasons: to subdue uncertainty, alleviate its concern of having the new emerging technology used against it in a surprise fashion, and prevent its competition from establishing dominance.[99] It has already been discussed that two of these reasons are true regarding hypersonic weapons; they create ambiguity and are most effective as a first-strike capability. The last the United States needs to analyze is if hypersonic weapons give the PLA and Russian militaries an advantage over it. Based on how new these weapon systems are, there is not enough academic information available to decide its tangible advantages. However, the ambiguous and surprise characteristics of hypersonic weapons are enough for the United States to conclude that hypersonic weapons will alter the global balance of power if it allows its adversaries to procure this disruptive technology without action.

[99] Heather Williams, "Asymmetric Arms Control and Strategic Stability: Scenarios for Limiting Hypersonic Glide Vehicles," *Journal of Strategic Studies*, 42. No. 6 (August 2019): 792, https://doi.org/10.1080/01402390.2019.1627521.

The second question that needs to be answered is if the United States believes its military is currently superior to its adversaries. If it does, it would be in its best interest to maintain the status quo. When it comes to states pursuing arms control agreements, it is usually the stronger state that seeks them to preserve its advantageous military status.[100] The United States is commonly accepted as the global military hegemon, so it would make sense to pursue arms control measures in order to maintain the status quo.

The final question the United States needs to answer is: what does a world without hypersonic weapon arms control look like? Determining the effects of hypersonic weapon technology acquisition by other competitors, allies, rogue states, and non-state actors will play a role in assisting the decision about diplomatic intervention by the United States. Two hypothetical scenarios by scholars who have studied hypersonics and its effects predict results that may make the United States want to prioritize preventing the proliferation of hypersonic weapons. Disruptive technologies expert Dmitry Stefanovich believes that, if hypersonic proliferation goes unchecked, a global security dilemma will ensue, and offensive and defensive capability zones will begin to overlap.[101] This would result in crisis instability on the multinational level with a threat of one state's—or non-state actor's—miscalculation resulting in a domino effect of hypersonic launches. Another scenario, posed by Dr. Carrie Lee, is also disturbing. In what closely resembles Stefanovich's prediction, Lee's concern is that the destabilizing effects of hypersonic weapons increases the likelihood of smaller regional powers launching a strike against the another and dragging their larger allies into the conflict.[102] The fact that the foundation of these scenarios take into account known attributes of hypersonic weapons and projects them outside of the current three players in the hypersonic arms race makes them a reality and should cause concern for the United States.

---

[100] Carrie Lee, "Technology Acquisition and Arms Control: Thinking Through the Hypersonic Weapons Debate.," *Texas National Security Review*, September 15, 2022, 15, https://tnsr.org/2022/09/technology-acquisition-and-arms-control-thinking-through-the-hypersonic-weapons-debate/.

[101] Dmitry Stefanovich, "Hypersonic Weapons and Arms Control," *Russian International Affairs Council*, April 6, 2020, 4, https://russiancouncil.ru/en/analytics-and-comments/analytics/hypersonic-weapons-and-arms-control/.

[102] Lee, 17.

The answer to the question of whether the United States should pursue arms control measures and agreements for hypersonics is yes, due to the three questions posed in this section. First, hypersonic weapons in the hands of the PRC and Russian military gives them a military advantage with the potential of altering the balance of power away from the United States. Second, the United States currently fields a superior military globally, and therefore should want to maintain the status quo. Third, allowing the proliferation of hypersonic weapons will create regional destabilization which will in turn eventually affect the United States. Now that it is determined that the United States needs to pursue arms control measures and agreements to end the hypersonic arms race, the next determination it needs to make is how it will do so.

2. Arms Control Measures/Agreements Available

The United States must pair its objectives and areas of focus with the numerous types of arms control measures available to maximize the effectiveness of a potential agreement with hypersonic-wielding states. Generally, arms control objectives involve preventing conflict and reducing strategic instability by limiting the negative effects of the weapons under consideration.[103] Assessing strategic instability is divided into two overarching categories: solving intelligence inequalities and balance of power concerns between states.[104] Arms control objectives include increasing transparency and predictability; and reducing motivation of a surprise attack, escalation, and chances of miscalculation between participating states.[105] The most destabilizing effects hypersonic weapons present are target ambiguity, warhead ambiguity, and first strike capability, all of which align with these general objectives.

Once objectives are identified, they can be branched out into areas of focus. Arms control agreements typically take one of three forms: creating transparency among states

[103] John Borrie, Amy Dowler and Pavel Podvig., *Hypersonic Weapons: A Challenge and Opportunity for Strategic Arms Control* (The United Nations Office for Disarmament Affairs, New York: The United Nations Publication, 2019), 26, https://www.un.org/disarmament/publications/more/hypersonic-weapons-a-challenge-and-opportunity-for-strategic-arms-control/.

[104] Lee, 14.

[105] Borrie, Dowler and Podvig, 26.

by providing information on the participants' inventory, limiting proliferation, or completely banning either the production and/or testing of the weapon system.[106] The two main areas which would be most relevant to hypersonic weapons are whether the United States should focus on limiting the spread of this emerging technology beyond the main three countries participating in the hypersonic arms race or limiting the use and development of hypersonics once they have been fielded by a state.[107] Determining the areas of focus allow for the United States to then begin to explore what types of measures are available that are most compatible with what all three states would want in an arms control agreement.

Arms control measures and agreements vary depending on the objectives, areas of focus, participants, and concessions. Agreements can be legally binding, politically binding, or voluntary in nature unilaterally, bilaterally, or multilaterally. The concessions involved can be quantitative or qualitative with like-for-like or asymmetric means. They can also be a combination of these things. If the United States decides to take a diplomatic approach to the hypersonic arms race, it needs to consider the pros and cons of each measure available.

If the United States decides to go the legal route, the only arms control agreement that would work in the hypersonic arms race is a multinational international legally binding agreement. The hypersonic arms race is a trilateral issue with the potential to expand to other states, and a study conducted by the United Nations Office for Disarmament Affairs determined that multilateral international legally binding regimes are "the most direct and robust way to address the issues raised by boost-glide systems."[108] For this reason, unilateral and bilateral options will not be explored in this thesis.

A multinational legally binding arms control agreement would create formality between the United States, China, and Russia and is possibly the most direct method to ending the hypersonic arms race. However, there would need to be unanimous agreement

[106] Lee, 14.

[107] Lee, 3.

[108] Borrie, Dowler and Podvig, 30.

on the exact terms drafted which is not a guarantee between competitors. Typically, legally binding agreements require forms of verification to make the terms presented acceptable to all parties. Verification measures proposed by the UN Office for Disarmament Affairs are "continuous monitoring systems, facilities declarations, inspections and regular data exchanges."[109] An advantage to accepting intrusive verification measures signals to the participants and the rest of the world that weapons stockpiled are intended for defensive or retaliatory use as opposed to purely offensive.[110] Though it seems that a multinational legally binding arms control agreement is the best answer to solving an arms race, there are many steps required in order for multiple nations to agree to terms that are mutually beneficial.

If the United States has a goal of pursuing legal means to diplomatically end the hypersonic arms race, it may need to first practice voluntary measures. Though voluntary measures can be a potential tool to be used by itself to potentially end an arms race, they can certainly be used to lay the foundation for bringing perspective states closer to agreeing to more formal measures.[111] The most common voluntary measures prescribed through arms race literature are transparency and confidence-building measures (TCBMs). Examples of TCBMs provided in the United Nations hypersonic study include: "the exchange of information on test flights, crisis communications, dialogue on risks, doctrines, strategies and policies, non-targeting statements, de-alerting, and the use of existing arms transparency instruments."[112] Additional voluntary measures include educational and awareness activities designed to expose as many international audiences as possible on the effects of hypersonic weapon systems.[113] Voluntary measures, contrary of legally binding agreements, are easy to execute but fail to yield direct results when used in isolation.

[109] Borrie, Dowler and Podvig, 30.

[110] Lee, 15.

[111] Williams, 809.

[112] Borrie, Dowler and Podvig, x.

[113] Borrie, Dowler and Podvig, xi

It can be concluded that if the United States decides to pursue hypersonic arms control, the general objectives previously listed all apply. Where the difficulty lies is where it decides to focus its efforts: implement information sharing procedures, limit the spread of hypersonic weapons beyond the three key players, or completely ban its use entirely. Whether the United States decides to focus on one or all these areas, it would then need to effectively identify the tools required to meet its objectives. Will it take the legal or voluntary route? Would like-for-like concessions work, or would asymmetric concessions be required to make all parties involved likely to reach an agreement? These are just examples of the many questions government leadership needs to answer if it decides to pursue arms control for hypersonic weapons.

3. Effects

Arms control on hypersonic weapons will not happen in a vacuum; there are many direct and indirect effects on the domestic population and international governments that could take place once the arms control process begins. Arms control effects are intended to be positive and beneficial to all parties involved, but there are some negative outcomes that can arise if not executed properly.

When discussing the strategic effects of arms control agreements earlier in this chapter, it was established that creating an environment that reveals information on stockpiles and easing balance of power concerns between participants are the desired outcomes. However, these effects are broad and are collectives of many different variables that need to be analyzed by the United States. According to Dr. Carrie Lee, the United States is currently approaching the hypersonic arms race too broadly, and "little systematic analysis has been conducted to identify which of the several changes hypersonic weapons introduces…there has been no effort to examine whether certain aspects of hypersonic weapons may, in fact, be stabilizing. As a result, arms control analysis risks developing solutions for the wrong problems, or even developing solutions that risk further destabilization."[114] By not taking into consideration the more detailed effects of

[114] Lee, 4.

hypersonic weapons and arms control agreements, the United States could potentially make its situation even worse.

Three main considerations of arms control need to be weighed prior to engaging in arms control negotiations, according to Lee; "strategic effects, domestic incentives, and potential costs associated with nonproliferation."[115] Domestically, leadership needs to consider how arms control affects its civilian population. Arms control agreements on hypersonic weapons would restrict the costs associated with production and acquisition, which could potentially reallocate resources towards critical public goods and services.[116] On the other hand, if a majority of the population believes that the United States' military advantage is eroding, there may be a call to pursue hypersonic weapons to level the playing field.[117] Key decision-makers need to determine how their constituencies feel about the hypersonic arms race when exploring arms control options.

The costs—from both a financial and interrelationship point of view—of arms control also need to be considered. Arms control measures and agreements can have significant impacts on domestic markets and international relations. Much of the technology used to develop hypersonic weapons are used by both military and commercial organizations, meaning that the restriction or total ban of this technology could negatively impact companies that depend on the production of certain system components to operate.[118] The United States would have to identify the individual components of hypersonic weapon technologies that is considered dual-use and identify if it can obtain its arms control objectives by allowing the continued production of dual-use technologies. Additionally, arms control agreements could strain the United States' international relationships with its allies. The restriction or banning of hypersonic weapons would disallow ally countries from obtaining them for themselves as well as preventing them from pursuing leverage over their own rivals.[119] Not allowing ally militaries to employ

[115] Lee, 14.

[116] Lee, 17.

[117] Lee, 17–18.

[118] Lee, 19.

[119] Lee, 19.

hypersonic systems could potentially force the United States to expend more resources to provide security for these nations, which could be more costly than an arms race. It is important for the United States to focus on striking an agreement with China and Russia, but it also cannot lose sight of its general population, commercial private sectors, and allies when negotiating arms control for hypersonic weapons.

4. Challenges

Arms control agreements do not happen just because the initiating state desires it; there are many challenges that can impede arms control measures and agreements from coming to fruition. The two most common challenges that can interrupt progress on hypersonic arms control agreements are failure to comprehend the competitors' perspective and underestimating qualitative effects over quantitative objectives.[120]

When dealing with other states in arms control negotiations, it is important for the United States to understand both the other nations' point of view of the terms presented as well as which aspects are seen as most important. Nuclear issues expert Dr. Heather Williams states that "strategic stability means different things to different states…some states may not always value stability as much as the others, if at all."[121] As previously stated, the United States would prefer to maintain the status quo via arms control on hypersonic weapons, but its adversaries will simply not engage in such talks if they like the direction in which the arms race is heading. If China and Russia did decide to entertain the United States in negotiations, the United States would need to ensure the terms were as near symmetrical as possible—from all points of view. There is currently mutual skepticism and a devaluation of general arms control effectiveness between the three great powers, which would eliminate any chance of one side accepting even the slightest asymmetries in an agreement.[122] Unless these vastly different political regimes can come to trust one another as well as be willing to accept asymmetric terms—the previous chapter

[120] Williams, 793–795.

[121] Williams, 793.

[122] Borrie, Dowler and Podvig, 26; Williams, 808.

reveals that the playing field is currently not level—the chances of achieving a multinational arms control agreement for hypersonic weapons is slim.

Another challenge that can prevent an agreement is prioritizing quantitative concessions without weighing qualitative effects. Qualitative improvements—like impacts on strategic effects, international relationships, and the commercial sector—are typically sought in conjunction with quantitative restrictions of the designated weapon. However, the qualitative improvements for one nation could potentially have negative effects against the other participant, which may increase instability between the parties involved in the arms control agreement.[123] For example, a quantitative-focused arms control agreement would seem to create parity between the three states from an arsenal standpoint; however, the United States would win the agreement since it will still have other advantages that caused China and Russia to pursue hypersonic weapons in the first place. Additionally, a quantitative-focused arms control agreement on hypersonics may not be required, because the issue may naturally resolve itself on its own. Dr. Lee suggests that "because the estimated costs of each missile are so high…countries are not likely to invest in significant numbers of them…[additionally], because the missiles are most useful in a first-strike scenario…countries do not need significant numbers of hypersonic missiles in order to use them effectively and still undermine strategic stability."[124] In order for the United States to overcome the challenge of overvaluing quantitative concessions when framing its arms control measures, it needs to first focus on the qualitative effects for all participants and then see how quantitative variables can be used to preserve the qualitative effects.

5. What Would Work?

For the United States to determine which arms control measures and agreements will work in the hypersonic arms race, it needs to avoid traditional methods and explore more modern proposals designed to address the contemporary threat. The Cold War produced cookie cutter bilateral arms control agreements that will simply not work in resolving the trilateral hypersonic arms issue because there are large hypersonic disparities

[123] Williams, 795.

[124] Lee, 16.

between China, Russia, and the United States. Two theories, asymmetric arms control and minimal nuclear deterrence, have been proposed with both hypersonic weapons and the three great powers in mind to form a more plausible solution for the United States.

U.S. leadership should avoid utilizing arms control agreements from the past—specifically ones that involved the United States, Soviet Union, and nuclear ICBMs—when constructing a proposal for the hypersonic arms race. Historically, arms control has primarily focused on increasing strategic stability by prioritizing quantitative like-for-like concessions.[125] Many of them were also bilateral; the United States only needed to calculate favorable terms for themselves and the Soviet Union. Previous subsections in this chapter have highlighted that qualitative concessions need to take more precedence over quantitative ones and arms control measures exponentially increases in a trilateral environment.

The first of two theories explored in this subsection takes a more modern approach towards hypersonic weapons and the great powers involved in the arms race concerning them. Asymmetric arms control, as defined by Dr. Williams, is "cooperative measures of self-restraint in which states make non-like-for-like exchanges, either quantitatively or qualitatively."[126] She takes this theory and divides it into three distinct categories: asymmetries of reductions, asymmetries of ceilings, and asymmetry across domains.[127] All three categories are possibilities for the United States to pursue, because they all operate under the assumption that disparity exists between the participants, which Chapter II of this thesis confirms to be true between the United States, China, and Russia.

Asymmetry of reductions involves the participating states agreeing to a set maximum limit on a certain capability which requires one state to make more reductions than the other to achieve the limit.[128] Even though there is a common concession being reduced in this scenario, each state will feel the effects differently depending on its

[125] Williams, 790–795.

[126] Williams, 790.

[127] Williams, 801.

[128] Williams, 802.

contemporary stockpiles at the time of the agreement. An example that can be used for hypersonic weapons is determining maximum limits on different components, like HGVs, HCMs, conventional warheads, and nuclear warheads.

Asymmetry of ceilings involves the participants agreeing to different limits on the designated weapon system.[129] This method or arms control focuses more on the qualitative concessions, because it allows for the involved states to agree to terms that alleviate national security concerns. For example, an asymmetry of ceilings agreement between the PRC and United States could involve allowing a larger hypersonic arsenal for China. This would make up for their acknowledged nuclear disparity when compared to the United States and maintain the mutual vulnerability their strategy aims to achieve.

Asymmetry of domains involves the participants agreeing to reductions of different capabilities, or "non-like-for-like exchanges."[130] An example for a hypersonic arms control agreement between the three great powers would be setting limits on the PRC's sea-based HCMs, Russia's hypersonic nuclear warheads, and the United States' conventional HGVs.

The second theory that could prove to diplomatically solve the hypersonic arms race is minimal nuclear deterrence. This theory is not new; however, senior researcher Dr. Tytti Erasto has suggested ways it could be applied to today's hypersonic issue. Minimal nuclear deterrence can be summarized as agreeing to the smallest number of nuclear warheads possible that still allows the participants to maintain a credible deterrence and second-strike capability.[131] As explained in Chapter II of this thesis, both the PRC and Russia blame the United States' advanced missile defense systems and CPS program as reasons for developing hypersonic weapon systems. By applying minimal nuclear deterrence theory to a trilateral hypersonic arms control agreements, individual state

[129] Williams, 803.

[130] Williams, 804.

[131] Tytti Erasto, "Revisiting 'Minimal Nuclear Deterrence': Laying the Ground for Multilateral Nuclear Disarmament," *SIPRI Insights on Peace and Security*, no. 2022/6 (June 2022): 13, https://doi.org/10.55163/XBNA9025.

hypersonic missile limits can be set to ensure each state can efficiently deter the other as well as maintain a second-strike capability. These numerical limits would need to be revisited periodically as technology and capabilities continue to advance.

Both the asymmetric arms control and minimal nuclear deterrence propositions have characteristics that gives the United States the best chance at bringing an arms control agreement to fruition in today's political climate. They both address the qualitative effects which caused the hypersonic arms race to occur in the first place as well as being suitable for trilateral negotiations. Individually, the two theories may not guarantee terms will be agreed upon, but combinations of them in addition to other measures can serve as a starting point for the United States when developing a proposal.

B. CURRENT HYPERSONIC ARMS CONTROL MEASURES AND AGREEMENTS

The attributes of hypersonic weapons present issues that have yet to be comprehensively addressed by the international community. There are currently no arms control agreements or measures in place that specifically target hypersonic missiles.[132] While this is likely because hypersonics are only now becoming a realistic threat, there are other arguments as to why this issue has yet to be resolved diplomatically. There are, however, multiple organizations that exist that could be modified to include hypersonic weapons that are discussed later in this section.

One potential reason is that today's arms control concepts lack the level of effort required to reach agreements. Policymakers are failing to keep pace with emerging disruptive military technology that change the characteristics of warfare, nor able to accurately identify destabilizing effects.[133] In regard to hypersonic weapons, there have been no formal solutions that have correlated their characteristics with global strategic stability.[134] Since hypersonic missiles are most beneficial for an initial first strike to provide opportunities for follow-on subsonic attacks, it is still unknown if a state having

[132] Williams, 796; Stefanovich, 3.

[133] Williams, 798; Carrie, 2.

[134] Carrie, 4.

an unmatched numerical advantage provides a state a strategic advantage.[135] Lastly, the United States has acknowledged that hypersonic arms control, along with other arms control agreements, make no sense to pursue without the inclusion of China and has withdrawn from multiple treaties and agreements to prove its point.[136] This and the other reasons stated seem to contribute to the current lack of desire to pursue arms control agreements by all three great powers.[137]

Though there are no agreements and measures in place solely dedicated toward hypersonics, there are multiple organizations that exist that are just a few modifications away from encompassing hypersonic missiles. Primarily, the Missile Technology Control Regime (MTCR) and the New Strategic Arms Reduction Treaty (New START) are the two agreements that have the potential to diplomatically solve the hypersonic arms race. Other organizations, bodies, and measures exist that can be applied to hypersonic weapons but would require more effort than the previously mentioned agreements.

1. Missile Technology Control Regime

The MTCR is a volunteer group of 35 states that seek to reduce the proliferation of vehicles capable of delivering weapons of mass destruction (WMD). The United States and Russia are members of the MTCR; however, China is not.[138] It categorizes these vehicles and their components into two categories: Category I is the stricter of the two and covers systems with ranges of at least 300 km and/or with payloads more than or equal to 500 kg, and Category II are systems less than Category I's parameters.[139] The MTCR annex lists equipment and technology—including dual-capable systems[140]—and their corresponding category to make it clear to states what they can and cannot export and/or import. The

[135] Carrie, 18.

[136] Carrie, 19.

[137] Carrie, 18.

[138] Kolja Brockmann and Dmitry Stefanovich, *Hypersonic Boost-Glide Systems and Hypersonic Cruise Missiles: Challenges for the Missile Technology Control Regime* (Stockholm: SIPRI, 2022), 8, https://doi.org/10.55163/BDYX5243.

[139] Borrie, Dowler and Podvig, 28.

[140] Brockmann and Stefanovich, 13.

MTCR is currently designed to prevent the international procurement of weapons like anti-ship cruise missiles ballistic missiles, and even though some components of hypersonic missiles are included in the annex,[141] there is still too much ambiguity within the regime's regulations that would make it difficult to answer the hypersonic arms conundrum without modifications.

The MTCR annex was designed to have loose definitions of qualifying weapon systems in order to give the regime the capability to make amendments as technology advanced and new specifications emerged. Consequentially, this forces members to rely on an extensive list of examples from which to base interpretations.[142] Though the parameters set for category I items is considered to cover most HGVs and HCMs, there are several loopholes in addition to the ambiguous definitions that can be exploited and allow for the unrestricted transfer of these weapon systems.[143]

The main loopholes for HGVs and HCMs involve how the regime classifies HGVs and HCMs, the payload parameters, and policy on states' space programs. The closest descriptions in the annex regarding HGVs and HCMs are "ballistic missile, unmanned aerial vehicle, and re-entry vehicle."[144] This disregards the in-flight maneuverability and unpredictable flight pattern characteristics of hypersonic weapons. This also creates difficulty in defining payload restrictions for these weapons. The MTCR has different payload definitions for cruise and ballistic missiles; for ballistic missiles, only the re-entry vehicle and munitions are counted towards the 500 kg limit, while only the separating mechanism, countermeasures, and munitions count for cruise missiles.[145] Additionally, hypersonic weapons that rely only on its kinetic energy would not fall under category I.[146]

141 Stefanovich, 3–4.

142 Brockmann and Stefanovich, 15.

143 Brockmann and Stefanovich, v.

144 Brockmann and Stefanovich, 15.

145 Brockmann and Stefanovich, 15.

146 Brockmann and Stefanovich, 15.

Another loophole that could be exploited is that a guideline that is followed by the MTCR is that it is "not designed to impede national space programs or intentional cooperation in such programs."[147] With unmanned space planes—which have subsystems and components in common with hypersonic missile technology—becoming more prevalent in space operations, hypersonic weapon systems could be transferred between states under the guise of a space vehicle.[148]

There is a lot of restructuring that would need to take place, but the MTCR is the largest international body in the best position to create stability. If the regime could entice the PRC to become a member, define hypersonics as its own weapon system, and remove the current grey areas in the annex, it has a chance to limit the hypersonic arms race.

2. New START

Another arms control agreement that could serve as the foundation to a diplomatic resolution of the hypersonic arms race is the New START treaty.[149] New START places numerical limitations on land-launched ballistic missiles with a range more than 5,500 km, sea-launched ballistic missiles with a range more than 600 km, and aircraft with a range more than 8,000 km capable of carrying nuclear armed cruise missiles.[150] This treaty applies to both nuclear and conventional strike capabilities, but does not include hypersonic missiles, because the treaty only covers "a weapon delivery vehicle that has a ballistic trajectory for over most of its flight path."[151] There is a clause in the treaty that allows either participant to propose additions to emerging offensive weapons, but there has yet to be any indication from both sides to consider hypersonics in New START.[152] Similar to the MTCR, New START requires modifications if it is going to be considered effective. First, it is a bilateral treaty between the United States and Russia and both states would

147 Brockmann and Stefanovich, 20.

148 Brockmann and Stefanovich, 21.

149 Putin announced in February 2023 that Russia has ceased participation in the treaty. At the time this chapter was written, New START was still in effect.

150 Borrie, Dowler and Podvig, 23.

151 Borrie, Dowler and Podvig, 23.

152 Borrie, Dowler and Podvig, 24.

need to figure out how to add China to the agreement. The second modification that would be required is removing the ballistic trajectory requirement. The participants need to bring up the issues of hypersonic missiles and find a way to have them included in the treaty since they are capable of the same amount of destruction and range as ballistic missiles.

3. Other International Organizations and Bodies

There are additional international organizations and regimes that were formed to address long-range missiles: The First Committee of the United Nations General Assembly, the Hague Code of Conduct against Ballistic Missile Proliferation (HCoC), the Wassenaar Arrangement, and Security Council resolution 1540.[153] None of these organizations specifically address HGVs and HCMs and both the Wassenaar Arrangement and HCoC do not hold China as a member.

The First Committee of the United Nations General Assembly meets annually and discusses items like international security, disarmament, and global issues. Though previous panels have yet to discuss boost-glide weapons,[154] hypersonic weapons can easily become an agenda item for resolution. Destabilizing effects, arms control, and non-proliferation are all topics previously resolved for weapon systems in this setting and could be applied to hypersonics as well.

The HCoC consists of 139 member states that have agreed to minimize the production and testing of ballistic missiles while also increasing the use of TCBMs.[155] While hypersonic missiles have not been specifically discussed within this organization as of 2019, the missile boosters used for HGVs do fall under the items covered in this multinational commitment.[156] For the HCoC to become effective in the hypersonic arms race, it needs to gain China as a member and include all components of HGVs and HCMs in the agreement.

---

153 Borrie, Dowler and Podvig, 27–29.

154 Borrie, Dowler and Podvig, 27.

155 Borrie, Dowler and Podvig, 28.

156 Borrie, Dowler and Podvig, 28.

The Wassenaar Arrangement is made up of 42 states that exercise export controls and TCBMs on dual-use technologies, ballistic missiles, and re-entry vehicles.[157] There are different categories, like the MTCR, that determine the extent of the restrictions. HGVs and HCMs are not specifically discussed in the arrangement, so placement is current left to interpretation.[158] Like the HCoC, the Wassenaar Arrangement could be effective by adding China and clearly defining a category for hypersonic weapon systems and components.

Lastly, United Nations resolution 1540 was passed in 2004 and concludes that all states shall implement laws to disallow non-state actors from developing and/or acquiring WMD or vehicles capable of delivering them.[159] If this resolution were to be amended to include conventional warheads and hypersonic HGVs, it could soothe some hypersonic proliferation concerns.

4. Relatable Measures

There are some TCBMs that have been used before—specifically between the United States and Soviet Union during the Cold War—that could be beneficial to adding stability to the hypersonic arms race. There is currently a crisis communications system in place between the United States and Russia that could be utilized to deconflict a hypersonic launch at a moment's notice that does not exist between the United States and China.[160] Other examples of relatable measures that can be applied are information exchanges on launches, sharing strategies, non-targeting statements, and de-alerting.[161]

C. HOW TO WIN WITH THE PEN

The path to victory in the hypersonic arms race using only diplomatic means will require a lot of time and reciprocation from both China and Russia, but it is possible. The

[157] Borrie, Dowler and Podvig, 29.

[158] Borrie, Dowler and Podvig, 29.

[159] Borrie, Dowler and Podvig, 29.

[160] Borrie, Dowler and Podvig, 33.

[161] Borrie, Dowler and Podvig, 33–34.

United States will need to implement a phased approach: commit to TCBMs, spread awareness on the destabilizing effects hypersonic weapons present, formally announce a desire for an arms control agreement, propose an asymmetrical trilateral legally binding agreement to China and Russia, and make considerable modifications to current arms control organizations. Implementing TCBMs and spreading awareness are things that the United States could do immediately. As trust and support grows as a result of these efforts, the next phase would be legal proposals and amending existing international instruments.

Three main TCBMs will be essential to establish an environment conducive of an agreement between international rivals: non-targeting statements for nuclear strike facilities, broadcasting of all non-hostile hypersonic launches, and establishing multiple forms of crisis communications. Since both the PRC and Russia blame the United States' CPS program as a key reason for the exploration of hypersonic missiles, the United States can assure them that it will not seek to eliminate second-strike capabilities by proclaiming nuclear strike sites and infrastructure as off-limits to CPS weapons. Another TCBM that would eliminate ambiguity is having a system in place where all hypersonic missile tests and other routine launches are announced in as far as advance as possible to avoid compressed decision timelines. Lastly, crisis communications need to be established by all three states to deconflict hypersonic launches in a timely manner. Voice and chat across multiple frequencies and departments would be required for both redundancy and guarantee success. These three TCBMs are voluntary measures which would counter target and warhead ambiguity as well as encourage deconfliction between leaders to avoid a crisis.

At the next session of the First Committee of the United Nations General Assembly, the United States needs to ensure that hypersonic weapons make the meeting agenda to spread awareness. Destabilizing effects of hyperonics needs to be brought to the forefront in this formal setting as well as publicly proclaiming the desire for arms control. Additionally, government-sponsored research papers and agreement proposals need to be published. The United States needs to make itself clear on its intentions to restrict hypersonic missiles on a global level.

Once the United States believes enough political trust has been gained from both China and Russia, it can begin to initiate legally binding arms control proposals. It is important that the initial agreement is trilateral, with the option to add other nations once a treaty is finalized between the United States, China, and Russia. This is to avoid potential outside influences that could sour the potential agreement, as well as set the standard for states that are pursuing hypersonic missiles. Based on the open-source documents explored in Chapter II and the arms control theories in this chapter, an asymmetry of domains with a minimal nuclear deterrence clause would be the best option available for the United States.

This proposal would take one destabilizing capability from each state, from the perspective of the other participants, and place limits on it. This proposal would place numerical limitations on the United States' regional missile defense systems, China's intercontinental HGVs, and Russia's nuclear warheads. The United States' missile defense systems—to include interceptors, sensors, and BMD platforms—that operate at an agreed upon range near China and Russia would need to be restricted. This would allow Russian and Chinese A2/AD systems to be effective against units operating nearby, achieving desired deterrence. Placing limits against China's intercontinental HGVs would eliminate the crisis instability caused from target ambiguity. This would prevent the oversaturation of homeland defense systems like the ground-based midcourse defense system. Lastly, Russia's nuclear warheads would be targeted in this agreement due to its large arsenal and shock-based operational concepts.

A minimal nuclear deterrence theory clause would also be included in this treaty that applies to both conventional and nuclear hypersonic missiles. The three states would need to come to an agreement to the minimum number of missiles that still achieves mutual deterrence. These numbers, as well as the limits from the asymmetry of domains, can always be revisited whenever one side deems it appropriate—like when more advances in military technology occurs.

Simultaneously, the United States needs to revisit the innerworkings of both the MTCR and New START treaty. To start, it needs to entice China in becoming a member

of both. Then amendments need to be made that include clear and concise definitions of HGVs and HCMs, properly categorize them, and set specific restrictions.

This phased approach was made to be simplistic, but the reality of the matter is that a lot needs to go in the United States' favor in order to win the hypersonic arms race diplomatically. Going all in on this option is high-risk, high-reward: the United States risks falling even farther behind in the hypersonic arms race if it implements TCBMs and does' not achieve the follow-on results of a legally binding agreement. However, if successful, the hypersonic issue will be resolved with formal agreements in place that are designed to adjust as advances in weapon systems happen.

This chapter was intended to argue how the United States could end the hypersonic arms race with China and Russia diplomatically, but there are other options that can be explored. The next chapter reviews how the United States can win the hypersonic arms race by prioritizing a missile defense system capable of detecting and defeating hypersonic weapons.

THIS PAGE INTENTIONALLY LEFT BLANK

IV. THE SHIELD: WINNING THE HYPERSONIC ARMS RACE WITH AN EFFICIENT HOMELAND MISSILE DEFENSE SYSTEM

This chapter describes how the development of an effective homeland missile defense system, capable of defeating hypersonic missiles, can win the hypersonic arms race for the United States.

The first section of this chapter examines the major requirements, strategic effects, domestic vulnerabilities, and common criticisms that the United States needs to consider as it makes defensive developments. The second section identifies current and future options the United States has for defeating hypersonic threats. The concluding section synthesizes the information from the first two sections and recommends the most achievable options. This chapter concludes that ignoring historical arms race paradigms, upgrading the current midcourse missile defense system, and relying more on the U.S. Navy's AEGIS Combat System are the best options.

A. HOMELAND HYPERSONIC MISSILE DEFENSE CONSIDERATIONS

As the United States begins to make progress towards modifying its missile defense system to counter the hypersonic threat, it needs to account for the following: basic requirements for hypersonic defeat, strategic effects caused by fielding the system, variables that contribute to the need of an advanced system, and criticisms it can expect to be met with as it continues production. This section highlights the major points of each consideration.

1. Requirements

If the United States wants to successfully defeat hypersonic weapons, there is a baseline of changes and additions to its contemporary missile defense system required to do so. This thesis determines, based on expert analysis, that realistic expectations for hypersonic missile defense functionality, modifications to existing missile defense components, and tailoring sensors and interceptors to the hypersonic threat are requirements for countering these emerging threats.

At the very least, an effective missile defense system must be able to perform all the functions of the kill chain: find, fix, track, target, engage, and assess. This is also referred to as "attending the missile threat's entire life cycle."[162] In order for a hypersonic missile defense system to be considered suitable, experts agree that it will require a combination of new approaches as well as modifications to legacy systems across the entire spectrum of missile defense capabilities to counter a hypersonic weapon's entire life cycle.[163] Additionally, multiple existing and new missile defense systems strategically layered across multiple domains—space, maritime, cyber, air, and land—are required to reduce hypersonic missile performance and buy reaction time for decisionmakers.[164] This includes sensors, interceptors, integration, operational concepts, and organizational modifications.[165]

a. Realistic Expectations

The first requirement for a homeland hypersonic missile defense system is the understanding by U.S. leadership that it cannot expect to field an active defense for every area in the continental United States. Instead, the missile defense system will need to be designed as a preferential defense system, or a system that can "credibly defend a select number of target areas lucrative to an adversary for their political, economic, or military impact."[166] The fact that there are only a limited amount of missile defense resources needs to be factored within U.S. defense policy to create a realistic critical asset and defended

[162] Tom Karako et al., *North America Is a Region, Too: An Integrated, Phased, and Affordable Approach to Air and Missile Defense for the Homeland (*Washington, DC: Center for Strategic & International Studies, 2022), 25, https://www.csis.org/analysis/north-america-region-too.

[163] Dahlgren and Karako, *Complex Air Defense,* 43; Larry Wortzel, *Hypersonic Weapons Development in China, Russia and the United States: Implications for American Security Policy,* Land Warfare Paper 143 (Arlington, VA: Association of the United States Army, 2022), 6, https://www.ausa.org/publications/hypersonic-weapons-development-china-russia-and-united-states-implications-american.

[164] Dahlgren and Karako, 30..

[165] Dahlgren and Karako, 3.

[166] Tom Karako et al., *North America Is a Region, Too*, 21–22.

asset list to ensure efficiency.[167] There are also strategic effects associated with this approach that will be explored in a future section of this chapter.

b. Changes to Existing Systems

Existing missile defense components could be useful to the United States in defeating hypersonic missiles by providing new missions to capabilities and information that would be required for newer systems.[168] Both of these components fit in the core requirements of a robust missile defense system of detecting and intercepting threats. Currently, the DOD has determined that upgrading AEGIS, the PATRIOT missile defense system, and the Terminal High Altitude Area Defense (THAAD) system will be required to bolster homeland hypersonic missile defense.[169] This "multi-mission applications" requirement would provide the DOD more flexibility in the usage of surface-to-air missiles like the Navy's Advanced Medium-Range Air-to-Air Missile (AMRAAM) and the Standard Missile-6 (SM-6); launchers like the Army's PATRIOT M903 launching station and the Navy's MK 41 Vertical Launching System; and the sensors associated with command, control, battle management, and communications (C2BMC).[170] Modifications to these systems would immediately give the United States hypersonic defense capabilities without the development of a new system and still fulfill the requirements needed to defeat hypersonic missiles.

Utilizing current missile defense systems against hypersonic missiles—currently designed to the ballistic trajectory missile threat—will require upgrades to keep pace with the unpredictable flight patterns of hypersonic missiles.[171] For the United States, this will

[167] Dahlgren and Karako, *Complex Air Defense*, 4; Karako et al., *North America is a Region, Too*, 22.

[168] Dahlgren and Karako, *Complex Air Defense*, 3; Karako et al., *North America is a Region, Too*, 23–26.

[169] Dahlgren and Karako, *Complex Air Defense*, 17.

[170] Karako et al., North America is a Region, Too, 23.

[171] Richard Weitz, *NATO's Hypersonic Challenge* (Tallinn, Estonia, International Centre for Defence and Security, 2022), 7, https://icds.ee/en/natos-hypersonic-challenge/.

mean making necessary modifications to C2BMC.[172] These modifications, according to Dahlgren and Karako, include integrating existing radars and sensors to feed raw data into the new hypersonic missile defense infrastructure in order to bolster detection and tracking.[173] The next subsection goes into more detail on hypersonic sensor requirements.

c. Sensor Requirements

When developing a hypersonic missile defense, coverage and efficiency are required for its sensors. Hypersonic missiles present a challenge for terrestrial-based sensors due to their maneuverability and altitude.[174] To counter these characteristics, a hypersonic homeland missile defense system will require a layer of sensors positioned in space to offset the disadvantages of earth-based sensors and maximize the capability of finding, fixing, tracking, targeting, engaging, and assessing hypersonic threats.[175] Additionally, these sensors will need to perform discrimination—the ability to distinguish hypersonic warheads from other decoys and countermeasures in the target complex—reliably and consistently.[176] There are certainly other attributes required by sensors in order to counter the hypersonic threat, but without the capability of detecting the threat from any launch point on the globe and accurately tracking it, a hypersonic missile defense system would be ineffective. Sensor requirements based on specific phases of missile flight will be examined later in this chapter.

---

[172] Lockheed Martin's Command, Control, Battle Management, and Communications (C2BMC) System takes inputs from various multi-domain sensors and weapon systems and produces a common tactical picture.

[173] Dahlgren and Karako, *Complex Air Defense*, 44; Karako et al., North America is a Region, Too, 26.

[174] Dahlgren and Karako, *Complex Air Defense*, 1.

[175] Dahlgren and Karako, *Complex Air Defense,* 3.

[176] David Barton et al., *Ballistic Missile Defense: Threats and Challenges* (College Park, MD: American Physical Society, 2022), 18, https://aps.org/policy/reports/popa-reports/upload/MissileDefense-Report-final.pdf.

d. Interceptor Requirements

In addition to hypersonic missile defense sensors, an interceptor designed to counter a hypersonic missile, like the GPI, is necessary for the United States.[177] The speed, maneuverability, unpredictability, and altitude of hypersonic missiles will require an interceptor capable of overcoming these characteristics. Regardless of the phase of flight the hypersonic missile is in, an effective interceptor will need to at least be capable of matching or exceeding the speed and acceleration of the threat, be immune to distraction tactics, and be geographically spaced to defend multiple areas.[178] A large number of interceptors would need to be employed to not only meet the geographic coverage requirement, but also to intercept a large salvo size strike conducted against the United States. It is estimated that 5,500 space-based interceptors providing coverage for the continental United States would need to be fielded in order to grant 30 seconds of decision time against a salvo size of 10.[179] Interceptor requirements based on specific phases of missile flight will be examined later in this chapter.

2. Strategic Effects

As the United States continues to make advancements in its missile defense technology, it needs to consider the strategic effects that result. Negative perceptions of the international community and impacts to U.S. national security policy need to be weighed and are examined in this subsection.

a. Negative Effects

Fielding a hypersonic missile defense will have a significant impact on international security policies and destabilizing effects associated with arms races. As explained in Chapter II , the advancement of U.S. missile defenses has led to its adversaries pursuing

177 Dahlgren and Karako, 3.

178 Barton et al., 18 and 35.

179 Barton et al., 39.

new disruptive military technologies in order to counter the defenses.[180] This vicious cycle—strong defenses leading to advancements in weapons which in turn develops stronger defenses and so on—has led arms control experts to consider missile defense systems to have destabilizing effects on strategic relationships between nuclear-armed states like China and Russia.[181] These effects have been proven to be true by the United States' contemporary missile defense system and therefore can be applied to its hypersonic missile defense system when it fields one.

An advanced hypersonic missile defense system could also have a significant negative impact on international space policies. As the attributes of hypersonic weapons are forcing missile defense assets to be placed in outer space to give states a chance at defending against them, fielding space-based interceptors will likely be viewed by others as weaponizing space.[182]

b. Positive Effects

There are, however, some positive effects of fielding a robust hypersonic missile defense system that the United States could benefit from. First, expanding the U.S. missile defense system, compared to acquiring a large arsenal of hypersonic weapons or any other offensive options, is less escalatory on an international scale.[183] This could potentially diminish or offset some of the negative effects involving U.S. adversaries listed previously. Second, the advancement of the missile defense system will influence future policy

[180] Kolja Brockmann and Dmitry Stefanovich, *Hypersonic Boost-Glide Systems and Hypersonic Cruise Missiles: Challenges for the Missile Technology Control Regime* (Stockholm: SIPRI, 2022), 8, https://doi.org/10.55163/BDYX5243.

[181] Brockmann and Stefanovich, 13; John Borrie, Amy Dowler and Pavel Podvig, *Hypersonic Weapons: A Challenge and Opportunity for Strategic Arms Control* (The United Nations Office for Disarmament Affairs, New York: The United Nations Publication, 2019), 16, https://www.un.org/disarmament/publications/more/hypersonic-weapons-a-challenge-and-opportunity-for-strategic-arms-control/.

[182] Barton et al., 42.

[183] Matthew Costlow, *Vulnerability is No Virtue and Defense is No Vice: The Strategic Benefits of Expanded U.S. Homeland Missile Defense*, Occasional Paper Volume 2, Number 9 (Fairfax, VA: National Institute Press, 2022), xiii-xiv, https://nipp.org/papers/vulnerability-is-no-virtue-and-defense-is-no-vice-the-strategic-benefits-of-expanded-u-s-homeland-missile-defense/.

decisions.[184] Reducing or eliminating vulnerabilities to the homeland will allow U.S. political leaders the opportunity to explore options not available while in a mutually vulnerable state as well as potentially reducing the risks associated with those options to an acceptable level.[185] This could potentially create more options for the United States regarding current issues like the invasion of Ukraine and the potential invasion of Taiwan.

c. Deterrence by Denial

The most impactful and commonly agreed upon strategic effect that an advanced missile defense system has is deterrence by denial. A robust missile defense shifts the balance of power in favor of the defender due to being able to absorb an attack without significant consequence which in turn drives up the cost for the adversary to continue its attack.[186] This will, according to Dahlgren and Karako, "increase uncertainty in an adversary's decision calculus and impose developmental costs on adversaries."[187] Deterrence by denial paired with the positive effects in the previous subsection would give the U.S. military leverage and time during times of conflict.

3. Why the United States Needs an Efficient Homeland Hypersonic Missile Defense

This thesis argues three main reasons the United States needs to advance its homeland missile defense system to a level that allows it to defeat hypersonic weapons. The first reason is the characteristics of hypersonic missiles, referred to as the hypersonic problem in this thesis, were developed by adversaries explicitly to defeat contemporary missile defense systems. The hypersonic problem leads to the second reason, which is that the United States' homeland defense system is deficient for defeating these threats. The

184 Costlow, xiv.

185 Costlow, xiv-xv.

186 Carrie Lee, "Technology Acquisition and Arms Control: Thinking Through the Hypersonic Weapons Debate.," *Texas National Security Review*, September 15, 2022, 8, https://tnsr.org/2022/09/technology-acquisition-and-arms-control-thinking-through-the-hypersonic-weapons-debate/; Costlow, xiii.

187 Dahlgren and Karako, *Complex Air Defense*, 2.

third reason is that there are strategic and doctrinal benefits that come with fielding a robust missile defense system.

a. The Hypersonic Problem

The capability of HGVs and HCMs makes them a significant threat to the U.S. homeland. These weapons operate outside altitude and speed thresholds of missile defense systems and maneuver in an unpredictable pattern.[188] A result of these characteristics, according to Richard Weitz, hypersonic weapons will "intensify surprise, compress decision-making time, strain existing command-and-control structures, and alter warfighting and escalation dynamics."[189] With adversaries pairing HGVs with their ICBMs, the hypersonic problem is now reality for the continental United States.[190]

The altitude and speed of hypersonic weapons exploits limitations in a terrestrial based missile defense system reaction time and coverage. With HCMs flying at altitudes between 20 km and 30 km and HGVs between 40 km and 100 km, it is assessed that an HCM traveling at Mach 10 only gives its target 3 minutes of warning time and an HGV traveling at Mach 6 gives 11 minutes of warning time.[191] In comparison to a traditional ICBM, it is estimated that the United States would have 25 minutes to react before detonation.[192] These estimations do not take into account a space-based missile defense system designed to track and target hypersonic weapons.

---

188 Carrie Lee et al., *Hindering the Spread of a new Class of Weapons* (Santa Monica, CA: RAND Corporation, 2017), 10, https://www.rand.org/pubs/research_reports/RR2137.html.

189 Weitz, 1.

190 Department of Defense, *Military and Security Developments Involving the People's Republic of China 2021* (Washington, DC: Department of Defense, 2021), 61, https://media.defense.gov/2021/Nov/03/2002885874/-1/-1/0/2021-CMPR-FINAL.PDF; Borrie, Dowler and Podvig, 10.

191 Lee et al., 11 and 15; Tong Zhao, "Conventional Challenges to Strategic Stability: Chinese Perceptions of Hypersonic Technology and the Security Dilemma," *Carnegie Endowment for International Peace*, July 23, 2018, 6, https://carnegieendowment.org/2018/07/23/conventional-challenges-to-strategic-stability-chinese-perceptions-of-hypersonic-technology-and-security-dilemma-pub-76894.

192 Lee et al., 16–17.

b. Current U.S. Defenses Are Ineffective

The previous subsection has already established that without an advanced space-based missile defense system, the United States will have a compressed timeline for reacting to a hypersonic strike conducted against its homeland. Current systems in place are not designed to defend against hypersonic threats.

The current BMD and C2BMC architecture could now be considered out of date. These systems have been assessed as requiring improvement in streamlining information; decision making times are prolonged due to multiple communications being required between various chain of commands before responding to an identified threat.[193]

The United States' primary homeland missile defense system, the Ground-based Midcourse Defense System (GMD) is incapable of defending against hypersonic missiles. This can be attributed to it being designed to defend against limited strikes from rogue nations such as Iran and North Korea. GMD was recently assessed as ineffective in a wartime environment due to its limitations in its interceptor analyzing sensor data mid-flight, discriminating warheads through the threat cloud during the midcourse phase, and defending against threats capable of high g-force maneuvers.[194]

Ground-based sensors, like the Long Range Discrimination Radar, Upgraded Early Warning Radars, and COBRA DANE Radar, lose their geostrategic advantages due to hypersonic missiles being capable of avoiding expected polar ballistic trajectories that older versions of these systems were designed to defeat.[195] Strategic locations selected during the Cold War have now been made obsolete.

c. Benefits

Developing a homeland hypersonic missile defense system has many benefits which the United States could take advantage of including changing the perception of its adversaries, maintaining forward deployed assets, and protecting critical homeland assets.

---

[193] Dahlgren and Karako, *Complex Air* Defense, 4; Karako et al., *North America is a Region, Too*, 46.

[194] Barton et al., 17–25; Lee et al., 9.

[195] Wortzel, Hypersonic Weapons Development in China, Russia and the United States, 7.

An advanced missile defense system affects both an adversary's theory of victory and perception of whether a strike against the United States is worth it or not. China and Russia view maintaining a credible threat against the U.S. homeland as a "politico-military victory."[196] If China and Russia believe they could conduct a conventional strike against the United States without triggering a nuclear response, meaning the United States' deterrence by punishment strategy has failed, it may see a U.S. non-nuclear retaliatory response as worth the risk of an attack.[197] A robust homeland missile defense system benefits the United States by disrupting these two adversarial thought processes on attacking the United States.

Other benefits of fielding a hypersonic missile defense system include continuing the operations of forward deployed forces in strategic theaters, the protection of critical military and non-military assets, more options for crisis stability, and increased readiness against a rapid military shift.[198]

4. Criticism

There are three primary criticisms that the United States needs to consider regarding the pursuit of a hypersonic homeland missile defense system.

The first two criticisms stem from a Cold War mentality, which is that "U.S. homeland vulnerability is both fundamentally an unchangeable reality and…a net positive for deterrence that should be preserved."[199] This strategy suggests that mutual vulnerability between great powers is inevitable and necessary for global peace. The first criticism is that the United States fielding an effective missile defense system will give both domestic and adversarial leadership first strike incentives; the United States, because it would not have to worry about a kinetic retaliation, and adversarial leadership because

196 Costlow, x.

197 Costlow, xi and xiv; Karako et al., *North America is a Region, Too,* 8.

198 Dahlgren and Karako, *Complex Air Defense*, 48; Costlow, xv; Karako et al., *North America is a Region, Too,* 8.

199 Costlow, ix.

they would feel pressured to strike first due to U.S. defensive capabilities.[200] The second criticism, which was conceived from the Cold War, is that advancing U.S. homeland missile defense capabilities would initiate an arms race and the destabilizing strategic effects associated with it.[201]

The third major criticism against a hypersonic missile defense system is that it is not cost effective; the sensors and interceptors employed will always cost the United States more than what the adversary spent on the hypersonic missile it employed.[202] For example, it is estimated that one ground-based interceptor (GBI) costs $70 million to produce.[203] On the other hand, the Congressional Budget Office (CBO) estimates an intermediate-range hypersonic missile would cost $41 million per unit.[204]

This section intended to identify some of the variables the United States needs to consider as it pursues the advancement of its homeland missile defense system. Fundamental system requirements, strategic effects, vulnerabilities, benefits, and critiques of this pursuit can assist decision makers while still in the low-to-mid technology readiness levels.

The next section will explore vulnerabilities found in hypersonic missiles and expert recommendations for how the United States can defeat hypersonic weapons with its missile defense system.

B. OPTIONS FOR DEFEATING HYPERSONIC WEAPONS

The United States needs to assess how to efficiently defeat hypersonic missiles directed at the homeland as well as understand the capabilities and limitations during each phase of the missile's flight. This section explores the opportunities the United States has

200 Costlow, xv-xvi.

201 Costlow, xviii.

202 Costlow, xvii.

203 Barton et al., 22.

204 Corinne Kramer, *U.S. Hypersonic Weapons and Alternatives*, CBO-58255 (Washington, DC: Congressional Budget Office, 2023), 46, https://www.cbo.gov/publication/58255.

for intercepting hypersonic missiles in all phases of its flight, as well as expert recommendations on how to achieve them.

1. How to Defeat Hypersonic Missiles

For the United States' hypersonic homeland missile defense system to be considered a success, it needs to consistently be capable of defeating hypersonic threats. Interception and the exploitations of hypersonic flight characteristics are the two main approaches for doing this.

As explained in the previous section, conducting a hard kill against a hypersonic missile requires a capable interceptor. Historically, the DOD's preferred method for defeating ballistic missile threats has been using hit-to-kill (HTK) assets which is essentially hitting a missile with a missile. However, HTK is not the only way to defeat a hypersonic missile in flight. The United States could turn to blast fragmentation, directed energy weapons, and particle clouds for hypersonic missile interception.[205] While there are concerns about using directed energy weapons against a hypersonic missile, like prolonged dwell times for effectiveness,[206] advancements would give the United States an alternative intercept opportunity to go along with its kinetic GPI.

The same characteristics that make hypersonic threats difficult to defend—speed and maneuverability—can be used against it. Maneuvering at Mach five or faster bleeds speed and increases aerodynamic and thermal stresses on the materials of the missile.[207] A hypersonic missile defense system that forces multiple maneuvers can increase the decision timeline for the United States and defeat the missile without conducting an intercept.[208]

Subsets of these two methods, interception and the exploitation of the characteristics of hypersonic flights, can potentially be employed during any of the phases

[205] Wortzel, 3.

[206] Lee et al., 14.

[207] Brockmann and Stefanovich, 6; Dahlgren and Karako, *Complex Air Defense*, 29.

[208] Brockmann and Stefanovich, 6; Dahlgren and Karako, *Complex Air Defense*, 29.

of a hypersonic missile's flight. The following subsections explore opportunities for missile defeat during the boost, midcourse or glide, and terminal phases of flight for HGVs and its intercontinental delivery vehicles.

a. Boost Phase

The boost phase of a missile is the first stage of its flight path and takes place when the delivery vehicle's rocket engines are still burning, but before the warhead has detached.[209] For intercontinental delivery vehicles, this phase of flight typically lasts three to five minutes.[210] The United States currently does not field an effective boost phase intercept capability, but developing one would enable it to defend a larger area compared to other phase interception attempts and to defeat the missile well before it reaches its intended target; in addition, such an intercept is theoretically easier to conduct because it would take place before the missile's quick maneuvering tactics.[211]

As the United States continues its pursuit of boost phase intercept capabilities, there are several variables it needs to consider: burn time, type of propellant, the missile's intended target, and speed of the interceptor need to be calculated prior to operation.[212] Understanding these considerations and applying them to the way the United States deploys its forces near enemy A2/AD systems as well of the types of platforms used in the AOR can begin to reveal why a boost phase intercept system has not yet been fielded. For example, it is assessed that a kinetic interceptor would need to have a flight speed of at least 5 km/s, be within 500 km of the interception point, and be launched less than a minute after the threat launches, which creates a "reach-versus-time challenge."[213] Additionally, a terrestrial-based interception platform would need to be directly under the interception point, meaning that certain threat trajectories would only be possible for boost phase interception with a terrestrial asset if it were stationed in adversarial states like China and

[209] Barton et al., 28.

[210] Barton et al., 13.

[211] Barton et al., 29.

[212] Barton et al., 30.

[213] Barton et al., 13 and 30.

Russia.[214] This means that an effective boost phase interception system would require forward deployed assets to have long station times near adversarial A2/AD systems as well as be capable of reacting to a launch in less than a minute of enemy launch.

Although it is difficult to develop a boost phase intercept capability, there are still plenty of options for the United States to pursue. Different interceptors—kinetic or directed energy—and platform types have their own pros and cons and need to be considered. Kinetic interceptors afford the combatant commanders more flexibility due to the numerous amounts of existing missiles; however, the exploding nature of them could degrade sensor capability when attempting to maintain tracking data on multiple salvo launches.[215] Lasers provide unlimited ammunition if the associated power supply remains capable; however, they can require up to twenty seconds of dwell time depending on range, altitude, and propellent type to defeat a threat in the boost phase.[216] Terrestrial based platforms, like kinetic interceptors, are plentiful and provide flexibility to grant capability against hypersonic threats. Whether the DOD decides to employ surface and/or air platforms, it will need to be capable of getting on-station in the time required for intercept.[217] Specific recommendations for interceptors and platforms will be covered later in this chapter.

b. Midcourse/Glide Phase

The midcourse, or glide, phase takes place after the delivery vehicle's booster has burned out and the warhead has separated from it.[218] This is a difficult stage to conduct an intercept for a midcourse missile defense system. The combination of low air drag and launch debris in this phase of flight creates a threat cloud that makes it hard for systems to identify where the warhead, only about a meter long, actually is.[219] Additionally, passive

[214] Barton et al., 31.

[215] Barton et al., 29.

[216] Barton et al., 42.

[217] Barton et al., 29.

[218] Barton et al., 17.

[219] Barton et al., 13–17.

countermeasures, attacks against midcourse defense sensors, and launching interceptors at undiscriminated targets can add even more complexity to the situation.[220]

Currently, the only U.S. capability primarily designated to defend its homeland against a long-range strike is the GMD system. The GMD system employs multiple sensors, radars, and GBIs based in Fort Greeley, Alaska, and Vandenberg Space Force Base, California, for homeland midcourse defense.[221] As the previous section explained, GMD has been assessed as ineffective in a wartime environment due to its inability to discriminate and defeat more modern threats.[222] An additional concern involves the number of interceptors available. Depending on the system's shooting strategy, which is classified, common defense strategies like shoot-look-shoot[223] could be counterproductive in conflict.[224] With a current arsenal of 44 interceptors, there is concern that effective decoys paired with a high salvo launch would result in wasting multiple GBIs against undiscriminated objects.[225]

There are opportunities for the United States to improve its homeland midcourse missile defense. As the United States makes modifications to existing systems as well as developing new ones, it needs to ensure there are multiple sensor layers capable of discriminating warheads through the threat cloud to maximize the number of efficient interception attempts.[226] The future addition of the Glide-Phase Interceptor (GPI) is too early in development to assess its effectiveness, but is being designed to exceed the speed

[220] Barton et al., 17–19.

[221] Barton et al., 13 and 20.

[222] Barton et al., 23–25.

[223] The shoot-look-shoot method refers to when a missile defense system launches an interceptor against an incoming threat, conducts a kill assessment utilizing sensor data, then launches an additional interceptor based on the kill assessment.

[224] Barton et al., 19.

[225] Barton et al., 22.

[226] Barton et al., 18–19.

and maneuverability of the hypersonic threats it is built to defeat.[227] Specific recommendations for interceptors and platforms will be covered later in this chapter.

c. Terminal Phase

The terminal phase of the missile's flight is the shortest phase of flight and is when the warhead has re-entered the atmosphere and requires interceptors to be placed near the enemy's intended target just to stand a chance at defeating the missile .[228] The DOD fields three systems within its missile defense system which were designed to defeat threats in the terminal phase of flight: the SM-6, THAAD, and PATRIOT Advanced Capability-3 (PAC-3).

The Navy's SM-6 is the only interceptor that has publicly been associated with defeating hypersonic missiles in the terminal phase of flight by the MDA.[229] The SM-6 is currently only compatible with the MK 41 VLS found on U.S. destroyers, cruisers, and AEGIS Ashore. Unless America decides to field AEGIS Ashore in the contiguous United States or modify other launchers to support the employment of them, utilizing SM-6 for homeland terminal defense is restricted to the range of the interceptor and warship.

Both THAAD and PAC-3 are designed to intercept ballistic and cruise missiles in the terminal phase of flight, can mobilize anywhere in the world, and are exceptional at discriminating warheads.[230] Specific recommendations for interceptors and platforms will be covered later in this chapter.

---

[227] John Sawyer, *Missile Defense: Better Oversight and Coordination Needed for Counter-Hypersonic Development*, GAO-22-105075 (Washington, DC: Government Accountability Office, 2022), 28; "GPI Scenario Animation," June 16, 2021, Missile Defense Agency, video, 7:51, https://www.youtube.com/watch?v=-q-ieXZgrhY.

[228] Barton et al., 5–6.

[229] "GPI Scenario Animation," June 16, 2021, Missile Defense Agency, video, 7:51, https://www.youtube.com/watch?v=-q-ieXZgrhY.

[230] "Terminal High Altitude Area Defense," Missile Defense Agency, accessed January 27, 2023, https://www.mda.mil/system/thaad.html; "PATRIOT Advanced Capability-3," Missile Defense Agency, accessed January 27, 2023, https://www.mda.mil/system/pac_3.html.

2. What Could Work?

Understanding when and how to defeat hypersonic missiles has led to expert recommendations on how to make a U.S. hypersonic missile defense a reality. There are broad and specific phase recommendations for the United States to consider.

a. General Homeland Missile Defense Recommendations

There are some general recommendations made by experts regarding what the future of the United States' missile defense system should look like. A broad recommendation is that the system needs to be active and comprehensive, meaning that the number of layers and assets within the architecture need to be maximized to stress the adversary's mission planning and provide birth-to-death tracking of the hypersonic threat.[231] Making advancements to the SM-6, PAC-3, and THAAD to make them capable of consistent hypersonic interception as well as integrating more joint sensors into the missile defense system would both improve the United States' defense in depth as well as give it multiple platforms to defend the homeland.[232] C2BMC is set to receive such an upgrade, with the Proliferated Warfighter Space Architecture (PWSA)[233] already being developed to facilitate global coverage of hypersonic missiles.[234] These recommendations align themselves with Karako et al's seven homeland missile defense principles of "preferential defense, multi-mission applications, attending to the full attack life cycle, defense in depth, balancing persistence with flexibility, throwing nothing away, and affordability."[235]

---

[231] Dahlgren and Karako, *Complex Air Defense*, 30–43; Costlow, xx; Weitz, *NATO's Hypersonic Challenge*, 7.

[232] Dahlgren and Karako, 17 and 44; Lee et al., 38.

[233] Previously referred to as the National Defense Space Architecture (NDSA)

[234] Kelley Sayler, *Hypersonic Missile Defense: Issues for Congress*, CRS Report No. IF11623 (Washington, DC: Congressional Research Service, 2023), 1–2, https://crsreports.congress.gov/product/details?prodcode=IF11623.

[235] Karako et al., North America is a Region, Too, 21–28.

b. Boost Phase Recommendations

Due to the long station times and being located close to the interception point requirements highlighted in the previous section, the DOD will need to decide which platforms satisfy these conditions. The best option for a terrestrial-based interception platform are aircraft and drones.[236] Commercial drones equipped with rocket or laser interceptors are a cheap option, can operate close to enemy launch sites, and are capable of long on-station times.[237] F-35 aircrafts armed with the AIM-260 Joint Advanced Tactical Missile, which is capable of maneuvering after being fired, gives the DOD an asset that can quickly get to station and conduct a boost phase intercept 100–200 km away from an enemy launch site.[238]

If getting the intercepting platform to the required location fast enough to conduct a boost phase intercept is too difficult, another recommendation is to be above the hypersonic threat. Placing interceptors in low Earth orbit overcomes the geographical and geopolitical difficulties associated with intercepting platforms being stationed near enemy coastlines.[239]

c. Midcourse/Glide Phase Recommendations

There are two main recommendations this thesis found that are both realistic and cost effective for the United States: making modifications to the current GMD system and utilizing warships with the AEGIS Combat System for homeland defense.

A National Academies report on the U.S. GMD system found that in order to make it effective in a modern battle scenario, new interceptors, a shoot-look-shoot strategy, and better discrimination capability would be required.[240] With only 44 interceptors assigned to the GMD system, a shoot-look-shoot strategy, or similar doctrines, would not be

[236] Barton et al., 28.

[237] Barton et al., 36–37.

[238] Barton et al., 37.

[239] Barton et al., 38.

[240] Barton et al., 25.

effective against an enemy with a large arsenal of long-range hypersonic missiles. To remedy this concern, the DOD needs to consider the development of a GMD interceptor capable of deploying multiple kill vehicles per launch as well as implement the Navy's SM-3 block IIA to maximize the effects of a single interceptor as well as increase the number of interceptors available for homeland missile defense.[241] As the number of interceptors increase within the GMD system's arsenal, building additional ground-based interceptor sites along the southern United States coast should also be considered.[242]

Another option for the DOD to advance its homeland midcourse missile defense is by using AEGIS cruisers and destroyers. It is estimated that fourteen AEGIS warships deployed near U.S. coastlines, equipped with SM-3 block IIA interceptors, would be able to conduct midcourse interceptions in defense of the entire continental United States.[243] The GPI, once completed, should replace the SM-3 block IIA for this homeland defense mission. A counter argument to this is that it places a tremendous burden on the employment of fleet assets.

d. Terminal Phase Recommendations

There were not many recommendations made by experts for bolstering terminal phase interception, utilizing THAAD being the most feasible option,[244] presumably because intercepting a hypersonic missile in earlier phases is preferred.

C. HOW TO WIN WITH THE SHIELD

This thesis argues that the United States can win the hypersonic arms race via defensive measures by doing three things: ignoring traditionalist ideals concerning arms races, advancing the GMD system, and relying more on the AEGIS Combat System for homeland missile defense. This is the quickest way the United States can render adversarial hypersonic missiles, intended for the U.S. homeland, ineffective. While this chapter has

241 Barton et al., 19–20.

242 Wortzel, 7.

243 Barton et al., 26; Wortzel, 7.

244 Barton et al., 17.

highlighted that there are more than three things required, these three things can be achieved most quickly, affordably, and effectively in relation to the other options until both the PWSA and GPI are operational.

As the United States seeks to expand its missile defense system, concerns about negative strategic effects needs to be rejected by U.S. leadership. The Cold War era paradigm that mutual deterrence facilitates peace between great powers glosses over the fact that millions of U.S. citizens are in a constant state of vulnerability to a destructive hypersonic strike. Additionally, ignoring international criticisms and developing a robust missile defense system would prevent adversaries from conducting conventional strikes that fail to meet the redlines for a U.S. nuclear retaliation and add a new level of deterrence by denial.

While rejecting international scrutiny should be the United States' first strategic priority, modifying the GMD system needs to be its first technical priority for homeland defense. While upgrades to MDS are on-going and will improve the integration of sensor data, command and control of MDS elements, and discrimination capabilities of GMD, there is still a lot to be desired when considering its interceptor and shooting doctrine. The MDS interceptor needs to be capable of exceeding the speed and maneuverability of the hypersonic threats that could be launched against the homeland, have multiple kill vehicles to combat large salvo launches, and have a robust communication system to enable consistent in-flight updates. Outfitting GMD with SM-6 and SM-3 block IIA interceptors may be a solution until either a more advanced ground-based interceptor is developed, or the GPI is completed. More interceptors allow for a shooting doctrine like shoot-look-shoot without worry of expending all available assets in a highly saturated engagement. Additionally, if there are not enough silos to accommodate an expanded number of interceptors, adding more sites across the continental United States needs to be considered.

While AEGIS warships have primarily been involved with regional missile defense in a forward-deployed environment, in the event of a scenario in which homeland defense becomes a priority for USNORTHCOM, AEGIS cruisers and destroyers may have to be employed in a homeland defense mission. Using cruisers and destroyers along both coasts of the United States adds an additional layer to the missile defense system which augments

GMD and provides redundancy in the event forward deployed assets fail. Utilizing seven AEGIS ships equipped with SM-3 block IIA interceptors homeported on the West coast and seven more on the East coast balances assets between both fleets and gives the same amount of coverage of the United States as the GMD system. As the surface Navy expands, and unmanned surface vessels become operational, there are possibilities of more flexibility for homeland missile defense missions for either manned or unmanned ships.

This chapter was intended to argue how the United States could end the hypersonic arms race using purely defensive assets and measures, but there are still more options to be explored. The next chapter reviews how the United States acquiring its own arsenal of hypersonic weapons could serve as a leap ahead against the PLA and Russia.

THIS PAGE INTENTIONALLY LEFT BLANK

V. THE SWORD: WINNING THE HYPERSONIC ARMS RACE BY ACQUIRING ITS OWN HYPERSONIC MISSILES

This chapter describes how the acquisition of hypersonic weapons can win the arms race for the United States over China and Russia. The first section of this chapter reviews the criteria for determining if hypersonic missiles have a significant impact on strategic stability and examines a wargaming scenario involving hypersonic weapons in a modern conflict. The second and third sections highlight potential consequences and benefits associated with hypersonic acquisition. The concluding section synthesizes the information from the first three sections and recommends the most achievable options. This chapter concludes that avoiding stovepipe hypersonic weapon systems and focusing on creating one HCM and one HGV capable of multi-platform employment, forward deploying these weapons, and using them as leverage for diplomatic negotiations is the best way forward.

A. CONSIDERATIONS

This thesis argues that the strategic impact both on and off the battlefield needs to be considered by the United States before it decides to acquire a large hypersonic missile arsenal. The following subsections explore these two considerations by analyzing Dr. Christopher Chyba's three critera regarding what makes an emerging technology impactful to strategic stability and a 2019 hypersonic weapons tabletop exercise conducted by the United Nations Institute for Disarmament Research (UNIDIR).

1. Significant Impact to Strategic Stability

In order to determine if hypersonic weapons have a significant impact to strategic stability, according to Dr. Chyba, the following factors need to be studied: "the pace of advances in, and diffusion of, this technology; the technology's implications for deterrence and defense; and the technology's potential for direct impact on crisis decision-

making."[245] This subsection takes each of Chyba's three factors and compares them with what has already been observed by states concerning hypersonic weapons.

The first factor, pace and diffusion, refers to whether the components of the emerging technology affect the speed of development as well as the ease by which it can be acquired.[246] In other words, once introduced on a global scale, how quickly did hypersonic missiles advance to the maturity level they are at today and how easy is it for other states to obtain them? One of the first modern hypersonic weapons, the Russian Avangard HGV, took about two years to go from testing to operational.[247] Days after Russia's test flights, China began its own tests and fielded its own hypersonic weapon capability nearly one year later.[248] The United States, Australia, India, France, Germany, South Korea, North Korea, and Japan are now projected to field their own hypersonic weapons sometime this decade.[249] Additionally, the numerous loopholes found within the MTCR create a conducive environment for hypersonic weapon proliferation.[250] The fast pace of the development of modern hypersonic weapons by Russia and their proliferation to China satisfies the first of Chyba's criteria.

The second factor, deterrence and defense, is about how destructive the emerging technology could be as well as if it could be used as a deterrence strategy.[251] Regarding destruction, Chyba requires the emerging technology to be capable of triggering a nuclear reaction from its target.[252] Using the United States as a reference, its Nuclear Posture

---

[245] Christopher Chyba, "New Technologies & Strategic Stability," *Daedalus* 151, no. 4 (Fall 2022): 153, https://doi.org/10.1162/daed_a_01795.

[246] Chyba, 153.

[247] Kelley Sayler, *Hypersonic Weapons: Background and Issues for Congress*, CRS Report No. R45811 (Washington, DC: Congressional Research Service, 2022), 14, https://crsreports.congress.gov/product/details?prodcode=R45811.

[248] Sayler, 17.

[249] Sayler, 10 and 20.

[250] Kolja Brockmann and Dmitry Stefanovich, *Hypersonic Boost-Glide Systems and Hypersonic Cruise Missiles: Challenges for the Missile Technology Control Regime* (Stockholm: SIPRI, 2022), v, https://doi.org/10.55163/BDYX5243.

[251] Chyba, 154.

[252] Chyba, 154.

Review states, "[U.S.] nuclear forces deter all forms of strategic attack. They serve to deter nuclear employment of any scale directed against the U.S. homeland or the territory of Allies and partners."[253] Since hypersonic weapons are capable of being nuclear or conventional[254] and are capable of intercontinental range,[255] it can be assumed that a hypersonic missile launch against the U.S. homeland could trigger a nuclear response. For deterrence, the 2022 NDS highlights hypersonic weapons as a long-term capability the United States intends to use for its deterrence by denial strategy.[256] The potential to both trigger a nuclear response and be used as a deterrence satisfies the second of Chyba's criteria.

Chyba's third criterion factor is effect on crisis decision-making.[257] Specifically, he asks if the emerging technology provides the user a first-strike capability that would make an adversary more likely to attack first or at the first sign of a potential strike to avoid surprise and if it significantly reduces the decision-making time of the target.[258] Given that the characteristics of hypersonic weapons make them best suited for conducting first strikes that could result in hair-trigger reactions[259] and decision-makers of targeted states potentially have a matter of minutes to respond to a hypersonic strike,[260] this confirms that

253 Department of Defense, *2022 National Security Strategy of the United States of America* (Washington, DC: Department of Defense, 2022), 7, https://www.defense.gov/National-Defense-Strategy/.

254 Department of Defense, *Military and Security Developments Involving the People's Republic of China 2021* (Washington, DC: Department of Defense, 2021), 61, https://media.defense.gov/2021/Nov/03/2002885874/-1/-1/0/2021-CMPR-FINAL.PDF.

255 Sayler, 14.

256 Department of Defense, 2022 National Security Strategy, 8.

257 Chyba, 156.

258 Chyba, 156.

259 Carrie Lee et al., *Hindering the Spread of a new Class of Weapons* (Santa Monica, CA: RAND Corporation, 2017), 17, https://www.rand.org/pubs/research_reports/RR2137.html.; Richard Weitz, "China's Hypersonic Missiles: Methods and Motives," *China Brief* vol 21, no. 15 (July 2021): 27; Chyba, 152.

260 Lee et al., 11 and 15; Tong Zhao, "Conventional Challenges to Strategic Stability: Chinese Perceptions of Hypersonic Technology and the Security Dilemma," *Carnegie Endowment for International Peace*, July 23, 2018, 6, https://carnegieendowment.org/2018/07/23/conventional-challenges-to-strategic-stability-chinese-perceptions-of-hypersonic-technology-and-security-dilemma-pub-76894.

hypersonic weapons' effect on decision-making during crisis has a significant impact to strategic stability.

As an emerging technology, hypersonic weapons fulfill all three of Chyba's prerequisites for determining significant impact to strategic stability. U.S. leadership needs to consider this impact as it begins to acquire its own hypersonic arsenal. Specific consequences and benefits of hypersonic weapon acquisition will be explored later in this chapter.

2. 2019 Hypersonic Weapons Tabletop Exercise Report

In 2019, the UNIDIR conducted a tabletop exercise with diplomatic and military experts from multiple countries to assess the effects of hypersonic weapons during war.[261] The UNIDIR found significant risks associated with, "ambiguity, compressed decision-making times and potential entanglement between conventional and nuclear conflict"[262] that will be referenced throughout this chapter. Since the use of modern hypersonic missiles has only been observed between a nuclear and non-nuclear power, Russia and Ukraine,[263] this exercise is selected as reference because it simulated a large-scale conflict between multiple nuclear powers.[264]

There were three key concluding observations made by the UNIDIR regarding hypersonic weapons. First, the hypersonic arms race could lead to multiple other emerging technology arms races due to the desire to defeat adversary defense systems among the great powers.[265] Second, hypersonic weapons give the operator new capabilities in conflict

---

[261] John Borrie and Daniel Porras, *Hypersonic Weapons for International Stability and Arms Control: Report on a UNIDIR-UNODA Turn-Based Exercise* (The United Nations Institute for Disarmament Research, New York: The United Nations Publication, 2019), 1, https://unidir.org/publication/implications-hypersonic-weapons-international-stability-and-arms-control-report-unidir.

[262] Borrie and Porras, 1.

[263] Brad Lendon, "What to Know About Hypersonic Missiles Fired by Russia at Ukraine," *CNN*, May 10, 2021, https://www.cnn.com/2022/03/22/europe/biden-russia-hypersonic-missiles-explainer-intl-hnk/index.html.

[264] Borrie and Porras, 7.

[265] Borrie and Porras, 11.

that have yet to be observed in battle.[266] Third, the characteristics of hypersonic missiles can influence its target into strategic miscalculation and other escalatory actions.[267]

It would benefit the United States to consider both Chyba's evaluation on how hypersonic weapons have a significant impact on strategic stability, as well as the findings of the UNIDIR during its hypersonic weapon scenario to weigh the pros and cons of acquiring these weapon systems. The following sections expand on the broad findings mentioned in this section and identifiy potential consequences and benefits the United States could expect to experience throughout the acquisition of hypersonic missiles.

B. POTENTIAL CONSEQUENCES

This section analyzes the potential consequences associated with acquiring hypersonic weapons for the United States. The destabilizing effects on the international level and financial requirements for fielding hypersonic capabilities need to be considered before making a long-term commitment.

1. Negative Strategic Effects

The first potential consequence the United States must weigh during the acquisition process are the negative strategic effects associated with hypersonic weapons. Possessing a weapon system with the speed, accuracy, ability to maneuver within the atmosphere, and ambiguity that hypersonic missiles have is escalatory to other states and destabilizes international security.[268] These hypersonic characteristics also remove the ability to signal

[266] Borrie and Porras, 11.

[267] Borrie and Porras, 11.

[268] Brockmann and Stefanovich, v and 4; Timothy Wright, "Hypersonic Missile Proliferation: An Emerging European Problem?" *EU Non-Proliferation and Disarmament Consortium*, no. 80 (May 2022): 12, https://www.iiss.org/blogs/analysis/2022/05/hypersonic-missile-proliferation-an-emerging-european-problem.

intent which could cause strategic miscalculations by the potentially targeted state.[269] These miscalculations could result in adopting a fire-on-warning defensive posture, firing against the United States first to avoid surprise, and accidental nuclear deployment.[270]

Acquiring hypersonic missiles could also have a significant impact on U.S. Allies. If the United States becomes capable of conducting accurate long-range strikes via hypersonic missiles, it may not need to have so many assets forward deployed to maintain deterrence against its adversaries. This could result in international relationships being strained with U.S. Allies, who rely on the presence and security the United States provides while operating near them.[271] The United States would have two options to prevent a negative impact to its strategic alliances: assist in the proliferation of hypersonic weapons to its allies or craft a new international security strategy that maintains the same deterrence and response times as forward deployed U.S. military assets.

These negative strategic effects were observed during the 2019 UNIDIR hypersonic tabletop exercise. The participants and analysts observed that, compared to other weapon systems, hypersonic weapons forced strategic miscalculation by intended target countries.[272] Even when some states with hypersonic weapon capabilities tried to utilize them purely as a deterrence, differing perceptions by other states always resulted in escalation.[273] Additionally, states that did not have hypersonic weapon capabilities sought to acquire them.[274] The exercise did not describe how hypersonic missiles affected the international relationships between allies.

---

[269] Carrie Lee, "Technology Acquisition and Arms Control: Thinking Through the Hypersonic Weapons Debate.," *Texas National Security Review*, September 15, 2022, 11, https://tnsr.org/2022/09/technology-acquisition-and-arms-control-thinking-through-the-hypersonic-weapons-debate/; John Borrie, Amy Dowler and Pavel Podvig, *Hypersonic Weapons: A Challenge and Opportunity for Strategic Arms Control* (The United Nations Office for Disarmament Affairs, New York: The United Nations Publication, 2019), 18, https://www.un.org/disarmament/publications/more/hypersonic-weapons-a-challenge-and-opportunity-for-strategic-arms-control/.

[270] Lee, 2–12; Lee et al., 17.

[271] Lee, 11.

[272] Borrie and Porras, Report on a UNIDIR-UNODA Turn-Based Exercise, 11.

[273] Borrie and Porras, 6–9.

[274] Borrie and Porras, 10.

2. Cost

Cost is listed as a potential consequence, because even though expenditures are necessary for all three options explored in this thesis, there is economic risk involved if the United States tries to reverse its hypersonic missile acquisition decision in the future. Weapon acquisition is a long-term commitment and is considered one of the most expensive policy decisions a state could make.[275] The CBO estimates that the effort to purchase 300 intermediate-range[276] hypersonic missiles, integrate them with platforms, and sustain them for twenty years would cost the United States nearly $18 billion.[277] This estimate does not consider the other DOTMLPF-P[278] costs associated with weapon acquisitions.

When acquiring hypersonic missiles, the United States needs to understand the hidden costs associated with pursuing new technologies. According to Lee, "Every new technology must be learned, which can require thousands of man-hours to train and equip personnel to understand and use the new system…These actions are not costless to an organization and must be weighed against the expected value of the technology."[279] The time required to conduct training, create new doctrine, and distribute required equipment across multiple military facilities and platforms is a long process that is difficult to reverse once it begins.

C. POTENTIAL BENEFITS

This section analyzes the potential benefits associated with acquiring hypersonic weapons for the United States. There are positive strategic effects and a variety of military uses from these systems the United States should consider.

---

[275] Lee, 3–5.

[276] 3,000-5,500 km.

[277] Corinne Kramer, *U.S. Hypersonic Weapons and Alternatives*, CBO-58255 (Washington, DC: Congressional Budget Office, 2023), 46, https://www.cbo.gov/publication/58255.

[278] Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities, and Policy.

[279] Lee, 5.

1. Positive Strategic Effects

There are potential benefits involving strategic effects that could make the United States' decision to acquire hypersonic missiles worth the risk. These beneficial strategic effects consist of bolstering both deterrence and leverage for the United States.

Regarding deterrence, it can be argued that hypersonic missiles will be required by the United States if it wants to maintain coercion and counter-force advantages over its adversaries.[280] Acquiring intercontinental-range hypersonic missiles matches with the DOD's CPS program which would significantly boost U.S. deterrence and credibility to both Russia and China.[281] Additionally, the accuracy of these missiles would give the United States a cheaper option of deterrence in comparison to less accurate systems that rely on multiple salvos for mission success.[282]

Acquiring new technologies has the potential to give both a military and diplomatic advantage to the United States. Obtaining hypersonic missiles could shift the balance of power in favor of United States, giving the advantage on the battlefield against adversaries that do not field them.[283] Diplomatically, strengthening its offense would give the United States more leverage in arms control negotiations and other similar diplomatic discussions.[284]

During the UNIDIR tabletop exercise, users found that the warhead ambiguity associated with hypersonic weapons gave them a "first-mover advantage."[285] Another observation that could be viewed as beneficial was that conflict involving ground and surface forces was actively avoided by participants whenever hypersonic weapons were

[280] Wortzel, Hypersonic Weapons Development in China, Russia and the United States: Implications for American Security Policy, 8; Lee, 7.

[281] Lee, 7–10.

[282] Lee, 7.

[283] Lee, 7.

[284] Richard Weitz, *NATO's Hypersonic Challenge* (Tallinn, Estonia, International Centre for Defence and Security, 2022), 12, https://icds.ee/en/natos-hypersonic-challenge/.

[285] Borrie and Porras, 9.

present in the region.[286] This could mean that while it is argued these weapons are escalatory, hypersonic missiles could possibly reduce regional conflict due to each side not wanting to be a target of a hypersonic strike.

2. Military Use

There are multiple uses for hypersonic weapons that would give the U.S. military an advantage during armed conflict. This subsection analyzes how the characteristics of hypersonic missiles could be harnessed to benefit the DOD.

In elementary terms, a hypersonic missile is the combination of the speed and range of a ballistic missile paired with the altitude and flight profile of a cruise missile.[287] This combination of attributes creates a missile with the speed, precision, and maneuverability that makes them difficult to defend and gives targets little warning time.[288]

These advantageous characteristics create benefits the DOD can utilize in modern conflict. Hypersonic weapons give U.S. leadership more options at times of war in the tactical, operational, and strategic levels.[289] A first-strike capability,[290] leadership decapitation,[291] flexibility of altering target in-flight,[292] and making enemy high value targets vulnerable at all times[293] are all possible with hypersonic missiles. Specifically, HCMs gives the United States additional land attack and anti-ship capabilities, and HGVs provide theater and strategic strike opportunities.[294]

---

286 Borrie and Porras, 10.

287 Dahlgren and Karako, *Complex Air Defense*, 1.

288 Brockmann and Stefanovich, 4; Lee, 6; Lee et al., 7.

289 Lee, 5.

290 Chyba, 152.

291 Lee, 6.

292 Lee et al., 8.

293 Timothy Wright, "Hypersonic Missile Proliferation: An Emerging European Problem?" *EU Non-Proliferation and Disarmament Consortium*, no. 80 (May 2022): 11, https://www.iiss.org/blogs/analysis/2022/05/hypersonic-missile-proliferation-an-emerging-european-problem.

294 Wright, 4.

The UNIDIR tabletop exercise discovered an additional military use not yet explored in this section. While strategic nuclear weapons are used primarily as a deterrence and are the last rung on the escalation ladder, participants found that hypersonic weapons had the same success and effect as a nuclear weapon when employed.[295] This allowed users to achieve accurate destructive fires without initiating a nuclear war, deeming hypersonic weapons "more 'usable' than traditional, nuclear-armed strategic systems."[296]

D. HOW TO WIN WITH THE SWORD

This thesis argues that the United States can win the hypersonic arms race via offensive measures by doing three things: integrating one common HCM and HGV across multiple platforms and domains, forward deploying these offensive capabilities within adversary A2/AD ranges and taking advantage of the leverage provided to initiate arms control negotiations with China and Russia.

In order to reduce cost and maximize the effectiveness of hypersonic weapons, the United States needs to prioritize the development of one common HGV and one common HCM capable of being employed by multiple platforms across multiple branches of service. Integrating the U.S. Army's Long-Range Hypersonic Weapon (LRHW)[297] into AEGIS warships[298] and Ohio-class submarines[299] combat systems would give the United States a theater and intercontinental hypersonic strike capability from the land, surface, and subsurface domains. Additionally, integrating the U.S. Air Force's Hypersonic Attack Cruise Missile (HACM) with the Zumwalt-class destroyer and Virginia-class submarine, both which are already being modified for hypersonic strike capability,[300] gives the United

295 Borrie and Porras, 5.

296 Borrie and Porras, 6.

297 Sayler, 5.

298 To include future ship classes like DDG(X) and FFG-62.

299 To include the Columbia-class submarines once completed.

300 Sam LaGrone, "Navy Details Hypersonic Missile Plan for Zumwalt Destroyers, Virginia Submarines," *USNI News*, November 3, 2022, https://news.usni.org/2022/11/03/navy-details-hypersonic-missiles-on-zumwalt-destroyers-virginia-submarines.

States regional land attack and anti-ship options from the air, surface, and subsurface domains.

As the United States begins to produce these missiles, it needs to ensure they are installed in forward deployed forces. This accomplishes three objectives for the United States: increases deterrence in the AOR, adds credibility to future warnings, and gives forces an effective counter-attack option in the event China or Russia decides to conduct an attack. Additionally, as shown in the UNIDIR exercise,[301] fielding hypersonic weapons in the vicinity of Taiwan may deter a Chinese invasion.

Lastly, the United States would need to take advantage of its newfound leverage gained from hypersonic weapons and negotiate effective arms control measures with China and Russia. As discussed in chapter two, the United States lacks leverage in arms control talks with China and Russia because those two states already field them while the United States does not. Acquiring hypersonic missiles, and operating them in the vicinity of its adversaries, could tip the balance of power back towards the United States.

This chapter was intended to argue how the United States could end the hypersonic arms race by acquiring its own hypersonic weapon capabilities. Now that the three main options have been argued for, the next chapter concludes how the United States should proceed in order to win the hypersonic arms race.

[301] Borrie and Porras, 10.

THIS PAGE INTENTIONALLY LEFT BLANK

VI. HOW THE UNITED STATES WINS THE HYPERSONIC ARMS RACE

A. CONCLUSION

This thesis has shown that each option available to the United States--arms control measures, making improvements to the missile defense system (MDS), and acquiring hypersonic missiles, which can be seen as the pen, the shield, and the sword--has its own pros and cons. It also needs to be understood that the choices made to win the hypersonic arms race do not happen in a vacuum; there are numerous international and domestic variables that need to be weighed. Specifically, the reactions of both allies and adversaries cannot be guaranteed. Therefore, this thesis argues that the best option for the United States is to take a *control the controllables* approach: it needs to make decisions that allow it to pioneer hypersonic strategy and control the narrative of the arms race. The United States needs to respond to the hypersonic arms race with only its own national interests and security in mind. This can be done by developing highly visible transparency and confidence-building measures (TCBMs), upgrading its homeland missile defense system, and acquiring hypersonic weapons for regional operations. These actions encompass methods from all three U.S. options (the pen, shield, and sword) that are both beneficial and do not rely on interactions with other states. These also need to be conducted while rejecting the possible negative views from both allies and adversaries. After these actions are taken, the United States can then begin to initiate formal arms control methods involving hypersonic weapons with the international community.

This thesis has analyzed the impact hypersonic missiles have on strategy and military combat systems in order to determine how the United States can best respond to China and Russia acquiring hypersonic weapons. The pros and cons of both diplomatic and military approaches have been considered in a search for the quickest, most affordable, and most effective approach to the hypersonic arms race.

Chapter II examined the strategy, capabilities, and limitations for the United States, China, and Russia involving hypersonic assets. This included the number and types of hypersonic missiles in production and currently employed, an assessment of whether the

U.S. missile defense system can exploit hypersonic weapons, and the research and development infrastructure involving hypersonic capabilities. It was verified that the United States is behind its adversaries in the hypersonic arms race; there is a lack of concurrence between governmental organizations regarding U.S. response to China and Russia, a hypersonic weapon is yet to be operational, and MDS requires modifications before it is capable of hypersonic missile interception.

Chapter III postulated how the United States could end the hypersonic arms race with diplomatic action. It examined the multiple variables, theories, and current governing organizations associated with arms control agreements. It concluded that the United States needs to first commit to the following TCBMs: non-targeting statements for nuclear strike facilities, international notification of all non-hostile hypersonic missile employments, and establishing crisis communications with China and Russia. Simultaneously, the United States needs to leverage its participation in international organizations to facilitate awareness and reforms. Specifically, China needs to be admitted into the Missile Technology Control Regime (MTCR) and hypersonic missiles need to be an agenda item at the next First Committee of the UN General Assembly. Only then will the chances of a trilateral hypersonic arms control treaty between the United States, China, and Russia be realistic.

Chapter IV proposed how the United States can win the hypersonic arms race by prioritizing its homeland missile defense system. It examined multiple MDS elements for potential U.S. consideration and what options are best for defeating hypersonic missiles. It concluded that modifying the MDS by improving the integration of sensor data, the ground-based midcourse defense's (GMD) discrimination capabilities, and overall command and control elements is required. Additionally, the employment of AEGIS cruisers and destroyers—and eventually unmanned floating magazines—on both U.S. coasts in a homeland defense mission increases the United States' chances for success against hypersonic threats.

Chapter V analyzed how the U.S. acquisition of hypersonic missiles could benefit it in the hypersonic arms race. It examined strategic effects, cost, military use, and a United Nations Institute for Disarmament Research (UNIDIR) tabletop exercise. It concluded that

the United States can win with an offensive-minded strategy by integrating one common hypersonic cruise missile (HCM) and hypersonic glide vehicle (HGV) within its forces, operating these forces within the Indo-Pacific and European AORs, and using this newfound leverage to negotiate arms control policies with China and Russia.

This final chapter concludes that the United States should control only what it is capable of controlling: promoting TCBMs to set the international standard for conduct with hypersonic weapons, continuing to develop its MDS to keep pace with emerging threats, and acquiring hypersonic missiles to allow it the ability to operate forward deployed forces without impediment. These determinations and recommendations are expanded on in the following subsections.

1. Establish TCBMs

If the United States is to leap ahead of China and Russia, it will first need total alignment among its leaders as to how they want to address the hypersonic threat. This means getting the Department of State (DOS) involved before Russia and China's hypersonic weapons become an even bigger issue for the DOD. As the acquisition of hypersonic missiles progresses, the DOS needs to initiate TCBMs to signal to the world exactly how the United States intends to conduct itself with hypersonic strike capabilities. Strategic ambiguity is not an effective method of employing hypersonic missiles, which themselves are ambiguous.

The TCBMs required to do this, as highlighted in Chapter III, are issuing non-targeting statements for nuclear strike facilities, announcing all non-hostile hypersonic launches, and establishing multiple forms of crisis communications. These three things require few resources to complete and establish a narrative that China and Russia can either agree to or reject. Additionally, these three TCBMs reduce the chances of strategic miscalculation[302] and answer China's concerns of the United States

[302] Lee, Technology Acquisition and Arms Control, 11.

employing conventional prompt strike (CPS) weapon systems against its small nuclear infrastructure.[303]

Regardless, the publication of these TCBMs on a global stage guarantees China's and Russia's responses will be witnessed by all and could reveal adversarial intent. This allows the United States to set the standard in hypersonic weapon conduct and can begin to establish international norms, which could potentially lead to more formal measures like arms control treaties.

2. Reject Mutual Vulnerability and Develop the Strongest Defense

Controlling what the United States can control means that it cannot allow China to maintain mutual vulnerability[304] and Russia to continue to attempt to deter the advancement of U.S. missile defense systems by blaming its development of hypersonic missiles on America.[305] The continued development of systems like the glide phase interceptor (GPI) and proliferated warfighter space architecture (PWSA) show that the United States intends to disregard how its adversaries feel about its MDS, however, there are additional options it needs to explore to maximize its homeland defense.

The first thing the United States needs to do regarding its homeland missile defense is repurpose the GMD system. Originally designed to deter rogue states from initiating an attack against its homeland, the United States needs to modify GMD's primary mission to defeating more advanced threats from all enemies. This will require employing an MDS interceptor capable of exceeding the speed and maneuverability of hypersonic threats, fielding multiple kill vehicles to counter large salvo sizes, and a C2 system that enables in-flight updates. Additionally, all kinetic interceptors need to be designed to integrate across all MDS platforms and systems for flexibility.

Secondly, USNORTHCOM needs to rely on the AEGIS Combat System more for homeland defense missions. Coastal patrols by AEGIS cruisers and destroyers—and

303 Zhao, Conventional Challenges to Strategic Stability, 2; Putin, Presidential Address, 1.

304 Zhao, 1.

305 Putin, 1.

eventually unmanned surface vessels—add additional floating magazines allowing more options for MDS shooting doctrines. These missions can be conducted during routine workups and patrols to avoid tethering Naval forces strictly to the NORTHCOM AOR.

Lastly, the United States must improve the MDS in an integrated system and joint operations manner. True integration needs to be prioritized, meaning every system and operator across all Services should be able to contribute to and execute the kill chain. This thesis recommends employing one kinetic interceptor that is compatible with multiple launchers. This would reduce cost by not only limiting the number of types of interceptors but reducing the DOTMLPF-P costs required to field and maintain the system.

3. One Common HGV and HCM

Similar to the recommendation about one common interceptor, the same needs to be applied to the U.S. acquisition of hypersonic missiles. As stated in Chapter V, the DOD needs to explore integrating the Army's long-range hypersonic weapon (LRHW) and Air Force's hypersonic attack cruise missile (HACM) within naval surface and submarine forces. This reduces cost and maximizes the effectiveness of employing hypersonic weapons. As these missiles begin to become operable, the DOD needs to ensure they are installed in forward deployed forces. As stated earlier, the United States can take advantage of establishing international norms in hypersonic conduct by adding credibility to its TCBMs. Secondary benefits include increasing deterrence in AORs, adding credibility to future warnings, and bolstering the offensive capabilities of forward deployed forces.

B. RECOMMENDATIONS FOR FUTURE RESEARCH

Because this thesis was designed to be unclassified in order to ensure wide dissemination, it did not make use of classified sources. Further work should be done, making use of classified reports from the Office of Naval Intelligence (ONI), the MITRE Corporation, Missile Defense Agency, Strategic Systems Program Office, and other formal reviews on the current state of hypersonic missiles to understand the relevance of the hypersonic arms race. Additionally, the technological requirements and scientific theories to develop hypersonic weapons and efficient missile defense systems were not thoroughly explored. These topics should be examined to better understand how the United States can

design an effective hypersonic missile, interceptor, and other MDS elements to make the best decision regarding the hypersonic arms race.

C. FINAL THOUGHTS

The hypersonic arms race poses a significant national security issue for the United States. China and Russia have developed hypersonic missiles that change international deterrence strategies and the way wars will be fought. The time for a U.S. reaction to this emerging technology is now; trying to navigate the potential reaction of the international community and other strategic impacts needs to be rejected. Instead, the United States should take a leadership role in establishing international norms, advancing its homeland missile defense system, and acquiring joint-capable hypersonic missiles. Once accomplished, the United States can begin to shift its focus towards more formal actions like reforming international arms control organizations by utilizing the leverage gained by its missile defense system and hypersonic missiles. The hypersonic arms race can be won by the United States by utilizing the pen after both its sword and shield surpass its adversaries.

LIST OF REFERENCES

Barton, David, Frederick Lamb, Laura Grego, James Wells, David Barton, Philip Coyle, Steve Fetter, Alec Gallimore et al. *Ballistic Missile Defense: Threats and Challenges*. College Park, MD: American Physical Society, 2022. https://aps.org/policy/reports/popa-reports/upload/MissileDefense-Report-final.pdf.

Bendett, Samuel, Jeffrey Edmunds, Anya Fink, Mary Chesnut, Dmitry Gorenburg, Michael Kofman, Kasey Stricklin et al. *Artificial Intelligence and Autonomy in Russia*. DRM-2021-U-029303. Arlington, VA: CNA, 2021. https://www.cna.org/our-media/newsletters/ai-and-autonomy-in-russia.

Borrie, John, Amy Dowler, and Pavel Podvig. *Hypersonic Weapons: A Challenge and Opportunity for Strategic Arms Control.* The United Nations Office for Disarmament Affairs, New York: United Nations Publication, 2019. https://www.un.org/disarmament/publications/more/hypersonic-weapons-a-challenge-and-opportunity-for-strategic-arms-control/.

Borrie, John, and Daniel Porras. The Implications of Hypersonic Weapons for International Stability and Arms Control: Report on a UNIDIR-UNODA Turn-Based Exercise. The United Nations Institute for Disarmament Research, New York: United Nations Publications, 2019. https://unidir.org/publication/implications-hypersonic-weapons-international-stability-and-arms-control-report-unidir.

Brockmann, Kolja and Markus Schiller. *A Matter of Speed? Understanding Hypersonic Missile Systems*. Stockholm: SIPRI, 2022. https://www.sipri.org/commentary/topical-backgrounder/2022/matter-speed-understanding-hypersonic-missile-systems.

Brockmann, Kolja, and Dmitry Stefanovich. Hypersonic Boost-Glide Systems and Hypersonic Cruise Missiles: Challenges for the Missile Technology Control Regime. Stockholm: SIPRI, 2022. https://doi.org/10.55163/BDYX5243.

Burke, Edmund, Kristen Gunness, Cortez Cooper, and Mark Cozad. *People's Liberation Army Operational Concepts*. RR-A394-1. Santa Monica, CA: RAND Corporation, 2020. https://www.rand.org/pubs/research_reports/RRA394-1.html.

Chyba, Christopher. "New Technologies & Strategic Stability." *Daedalus* 151, no. 4 (Fall 2022): 150–170. https://doi.org/10.1162/daed_a_01795.

Clark, Colin. "'Hundreds' of China Hypersonic Tests Vs. 9 US; Hyten Says U.S. Moves Too Slowly." *Breaking Defense*, October 28, 2021. https://breakingdefense.com/2021/10/hundreds-of-china-hypersonic-tests-vs-9-us-hyten-says-us-moves-too-slowly/.

Costlow, Matthew. *Vulnerability is No Virtue and Defense is No Vice: The Strategic Benefits of Expanded U.S. Homeland Missile Defense*. Occasional Paper Volume 2, Number 9. Fairfax, VA: National Institute Press, 2022. https://nipp.org/papers/vulnerability-is-no-virtue-and-defense-is-no-vice-the-strategic-benefits-of-expanded-u-s-homeland-missile-defense/.

Dahlgren, Masao, and Tom Karako. *Complex Air Defense: Countering the Hypersonic Missile Threat*. Lanham, MD: Center for Strategic & International Studies, 2022. https://www.csis.org/analysis/complex-air-defense-countering-hypersonic-missile-threat.

Department of Defense. *2022 National Security Strategy of the United States of America*. Washington, DC: Department of Defense, 2022. https://www.defense.gov/National-Defense-Strategy/.

Department of Defense. *Military and Security Developments Involving the People's Republic of China 2021.* Washington, DC: Department of Defense, 2021. https://media.defense.gov/2021/Nov/03/2002885874/-1/-1/0/2021-CMPR-FINAL.PDF.

Dolan, John, Richard Gallagher, and David Mann. *Hypersonic Weapons – A Threat to National Security*. Palo Alto, CA: RealClear Defense, 2019. https://www.realcleardefense.com/articles/2019/04/23/hypersonic_weapons__a_threa_to_national_security_114358.html.

Erasto, Tytti. "Revisiting 'Minimal Nuclear Deterrence': Laying the Ground for Multilateral Nuclear Disarmament." *SIPRI Insights on Peace and Security*, no. 2022/6 (June 2022): 1–26. https://doi.org/10.55163/XBNA9025.

Fasola, Nicolo. *How Russia Fights.* No. 12. Roma, Italy: NATO Defense College Research Division, 2022. https://www.ndc.nato.int/about/organization.php?icode=168.

Fesler, Peter, and Terrence O'Shaughnessy. *Hardening the Shield: A Credible Deterrent & Capable Defense for North America*. Washington, DC: Wilson Center, 2020. https://www.wilsoncenter.org/publication/hardening-shield-credible-deterrent-capable-defense-north-america.

Global Security. "Intermediate Range Conventional Prompt Strike Weapon System." Accessed January 29, 2023. https://www.globalsecurity.org/wmd/systems/cps.htm

Griffin, Michael, and Patrick Shanahan. "Media Availability With Deputy Secretary Shanahan and Under Secretary of Defense Griffin at NDIA Hypersonics Senior Executive Series." Interview, December 13, 2018. https://www.defense.gov/News/Transcripts/Transcript/Article/1713396/media-availability-with-deputy-secretary-shanahan-and-under-secretary-of-defens/.

Hadley, Greg. "Kendall: China Has Potential to Strike Earth From Space." *Air & Space Forces Magazine*. September 20, 2021. https://www.airandspaceforces.com/global-strikes-space-china-frank-kendall/.

Hudson Institute. March 11, 2019. "China's Hypersonic Missile Advances and U.S. Defense Responses." Video, 58:42. https://www.hudson.org/events/1662-china-s-hypersonic-missile-advances-and-u-s-defense-responses32019.

Hummel, Robert. "The Hypersonic Conundrum." *STEPS* Issue 6 (April 2022): 57–60. https://www.potomacinstitute.org/steps/featured-articles/april-2022/the-hypersonic-conundrum.

Karako, Tom, Ian Williams, Wes Rumbaugh, Ken Harmon, and Matt Strohmeyer. *North America Is a Region, Too: An Integrated, Phased, and Affordable Approach to Air and Missile Defense for the Homeland*. Washington, DC: Center for Strategic & International Studies, 2022. https://www.csis.org/analysis/north-america-region-too.

Kramer, Corinne. *U.S. Hypersonic Weapons and Alternatives.* CBO-58255. Washington, DC: Congressional Budget Office, 2023. https://www.cbo.gov/publication/58255.

LaGrone, Sam. "Navy Details Hypersonic Missile Plan for Zumwalt Destroyers, Virginia Submarines." *USNI News*, November 3, 2022. https://news.usni.org/2022/11/03/navy-details-hypersonic-missiles-on-zumwalt-destroyers-virginia-submarines.

Lee, Carrie, Richard Speier, George Nacouzi, Carrie Lee, and Richard Moore. *Hypersonic Missile Nonproliferation: Hindering the Spread of a new Class of Weapons*. Santa Monica, CA: RAND Corporation, 2017. https://www.rand.org/pubs/research_reports/RR2137.html.

Lee, Carrie. "Technology Acquisition and Arms Control: Thinking Through the Hypersonic Weapons Debate." *Texas National Security Review*, September 15, 2022. https://tnsr.org/2022/09/technology-acquisition-and-arms-control-thinking-through-the-hypersonic-weapons-debate/.

Lendon, Brad. "What to Know About Hypersonic Missiles Fired by Russia at Ukraine." *CNN*. May 10, 2022. https://www.cnn.com/2022/03/22/europe/biden-russia-hypersonic-missiles-explainer-intl-hnk/index.html.

Millsaps, Knox. "Hypersonics Overview Office of Naval Research: Strategy and Discussion Group." Presentation at Washington, DC, October 26, 2022.

Missile Defense Agency. "GPI Scenario Animation." June 16, 2021. Video, 7:51. https://www.youtube.com/watch?v=-q-ieXZgrhY.

Missile Defense Agency. "PATRIOT Advanced Capability-3." Accessed January 27, 2023. https://www.mda.mil/system/pac_3.html.

Missile Defense Agency. "Terminal High Altitude Area Defense." Accessed January 27, 2023. https://www.mda.mil/system/thaad.html.

Office of the Under Secretary of Defense Chief Financial Officer. *Defense Budget Overview: United States Department of Defense Fiscal Year 2023 Budget Request*. 3–364B8D0. Washington, DC: OSD, 2022.

Putin, Vladimir. *Presidential Address to the Federal Assembly*. Saint Petersburg, Russia. March 1, 2018. en.kremlin.ru/events/president/news/56957.

Saalman, Lora. "China's Calculus on Hypersonic Glide." *Stockholm International Peace Research Institute*. August 15, 2017. https://www.sipri.org/commentary/topical-backgrounder/2017/chinas-calculus-hypersonic-glide.

Sawyer, John. Missile Defense: Better Oversight and Coordination Needed for Counter-Hypersonic Development. GAO-22-105075. Washington, DC: Government Accountability Office, 2022.

Sayler, Kelley. *Hypersonic Missile Defense: Issues for Congress*. CRS Report No. IF11623. Washington, DC: Congressional Research Service, 2023. https://crsreports.congress.gov/product/details?prodcode=IF11623.

Sayler, Kelley. *Hypersonic Weapons: Background and Issues for Congress*. CRS Report No. R45811. Washington, DC: Congressional Research Service, 2022. https://crsreports.congress.gov/product/details?prodcode=R45811.

Shyu, Heidi. "Under Secretary of Defense for Research and Engineering Heidi Shyu Remarks at The Hill Virtual Event on 'National Security at the Speed of Sound: Hypersonics in American Defense.'" Interview, The Hill, October 18, 2022. https://www.defense.gov/News/Transcripts/Transcript/Article/3192611/under-secretary-of-defense-for-research-and-engineering-heidi-shyu-remarks-at-t/.

Stefanovich, Dmitry. "Hypersonic Weapons and Arms Control." *Russian International Affairs Council*, April 6, 2020. https://russiancouncil.ru/en/analytics-and-comments/analytics/hypersonic-weapons-and-arms-control/.

Turner, Patrick, and Marcus Weisgerber. *SecDef Austin Summons Hypersonics CEOs*. Washington, DC: Defense One, 2022. https://www.defenseone.com/technology/2022/01/secdef-austin-summons-hypersonics-ceos/361229/.

Weitz, Richard. "China's Hypersonic Missiles: Methods and Motives." *China Brief* vol 21, no. 15 (July 2021): 24–29.

Weitz, Richard. *NATO's Hypersonic Challenge*. Tallinn, Estonia: International Centre for Defence and Security, 2022. https://icds.ee/en/natos-hypersonic-challenge/.

Williams, Heather. "Asymmetric Arms Control and Strategic Stability: Scenarios for Limiting Hypersonic Glide Vehicles." *Journal of Strategic Studies* 42, no. 6 (August 2019): 789–813. https://doi.org/10.1080/01402390.2019.1627521.

Wolfe, Frank. "Shyu Says Hypersonic Weapons Just One 'Arrow' in DOD Quiver, While Rep. Lamborn Argues for Parity." *Defense Daily*, October 18, 2022. https://www.defensedaily.com/shyu-says-hypersonic-weapons-just-one-arrow-in-dod-quiver-while-rep-lamborn-argues-for-parity/advanced-transformational-technology/.

Woolf, Amy. *Conventional Prompt Global Strike and Long-Range Ballistic Missiles: Background and Issues*. CRS Report No. R4164. Washington, DC: Congressional Research Service, 2021. https://crsreports.congress.gov/product/details?prodcode=R45811.

Wortzel, Larry. *Hypersonic Weapons Development in China, Russia and the United States: Implications for American Security Policy*. Land Warfare Paper 143. Arlington, VA: Association of the United States Army, 2022. https://www.ausa.org/publications/hypersonic-weapons-development-china-russia-and-united-states-implications-american.

Wright, Timothy. "Hypersonic Missile Proliferation: An Emerging European Problem?" *EU Non-Proliferation and Disarmament Consortium*, no. 80 (May 2022): 1–20. https://www.iiss.org/blogs/analysis/2022/05/hypersonic-missile-proliferation-an-emerging-european-problem.

Zhao, Tong. "Conventional Challenges to Strategic Stability: Chinese Perceptions of Hypersonic Technology and the Security Dilemma." *Carnegie Endowment for International Peace*. July 23, 2018. https://carnegieendowment.org/2018/07/23/conventional-challenges-to-strategic-stability-chinese-perceptions-of-hypersonic-technology-and-security-dilemma-pub-76894.

THIS PAGE INTENTIONALLY LEFT BLANK

INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center
   Ft. Belvoir, Virginia

2. Dudley Knox Library
   Naval Postgraduate School
   Monterey, California

DUDLEY KNOX LIBRARY

NAVAL POSTGRADUATE SCHOOL

WWW.NPS.EDU

WHERE SCIENCE MEETS THE ART OF WARFARE