Accelerating Solutions to Defend Against Hypersonic Threats

CAPSTONE PAPER FOR HYPERSONIC DEFENSE

Presented as part of the
Global Space and Defense Program
Price School of Public Policy
Viterbi School of Engineering
University of Southern California
Los Angeles, CA

27 April 2024

Table of Contents

Problem Statement

The United States requires new hypersonic defense capabilities to counter corresponding hypersonic and highly maneuverable threats from China and Russia. However, despite considerable investments being made in various programs in recent years, current evidence indicates that delivery of these capabilities does not match the sense of urgency needed to counter existing threats, which will increase substantially over the next decade. This report examines the current state of the hypersonic threat, the capabilities needed for hypersonic defense, the current state of investments, prioritization to achieve these capabilities, and whether opportunities exist to field solutions more rapidly in the near-term.

Introduction

Despite numerous tests of hypersonic and highly maneuverable weapons by China and Russia since 2016, including China's demonstration of a Fractional Orbit Bombardment System (FOBS) in 2021 and Russia's continued use of hypersonic weapons in Ukraine, the U.S. capability to defend against such weapons has struggled to keep pace with threat advancements. During testimony to the U.S. Senate Armed Services Subcommittee on Strategic Forces regarding the hypersonic weapons threat, Air Force General Glen Van Herck testified that he believes "the greatest risk for the United States stems from our inability to change at the pace required by the changing strategic environment" (Vergun, 2023, para. 5). On the U.S. ability to defend against hypersonic threats, Admiral Jon Hill, then Director of the Missile Defense Agency, explained "Aegis SBT [Sea-Based Terminal] is the only active defense available today to counter hypersonic missile threats" (Vergun, 2023, para. 15). Furthermore, Hill said that MDA will "deliver the next SBT incremental upgrade in 2025" (Vergun, 2023, para. 14).

This report will provide a thorough review of the current hypersonic threat, including what drove the development environment, the latest history of flight tests and usage in real-world conflicts of hypersonic weapons, and why hypersonic defense is unique and necessary to ultimately gain advantage against these challenging threats. That will be followed by detailed analysis of Department of Defense investments in hypersonic defense, reviewing the acquisition strategy, and budget allocation for various defense capabilities in recent years. Based on this research, recommendations will be made for changes to acquisition strategy to raise urgency, align objectives efficiently, and iterate more quickly to outpace threat development.

Research Design/Methodology

Descriptive research will be used to gather data to understand the existing conditions, trends, and characteristics of the threat. Descriptive research methodology will be used for the background and primary research question to describe the situation. This methodology will provide insight into the current state for both the threat and the response from the acquisition community to counter that threat.

Grounded theory methodology will primarily be used for the secondary research questions where theories will be constructed by systematically reviewing qualitative data gathered in the primary research question and in the background data. Case study design may be used where the specific primes or component technology is studied to gather an in-depth understanding of the outcomes, but it will not be the primary research method.

This project relies on four specific methods to derive its primary findings. First, it relies on root cause analysis to identify and explain why the United States is currently being outpaced in a competitive balance between its hypersonic defense capabilities and foreign offensive hypersonic missile capabilities (Han, 2023). Second, the project applies comparative budgetary analysis techniques to 1) establish a baseline understanding of U.S. investment patterns in hypersonic missile offensive and defense technologies and capability development programs and 2) depict trends in these patterns over time. The case study research method is also applied in a vignette illustrating how organizational inefficiencies in the missile defense enterprise are complicating the need to minimize duplication of effort and maximize focused application of resources on operational solutions in developing the missile defense system's future space sensor layer. Finally, the project framed its understanding of the development of U.S. hypersonic missile defense capabilities within "social circumstances," involving a complex interplay of domestic political, organizational, policy, and strategic factors. This approach was crucial to reaching the primary finding that social factors are the critical source of the U.S. lagging behind in this competitive balance. This approach has more explanatory power than alternative methods of viewing the situation through the lens of technological determinism or the actions of a rational, unitary U.S. government actor (Mackenzie, 1990).

Primary and Secondary Research Questions

Primary: What has the Department of Defense (DOD) done to date to develop and field hypersonic defense capability? Why is the U.S. being outpaced, and why will it take a decade to field an integrated hypersonic defense? What are the root causes of not having a defensive capability?

Secondary: What are the solutions to enable fielding of a hypersonic defense capability? What changes should be made to the acquisition strategy to raise urgency, prioritize, streamline, and consolidate efforts to enable a counter hypersonic capability sooner than current fielding plans?

Executive Summary

According to HowStuffWorks, Mach is a unit of velocity named after an Australian physicist, Ernst Mach (Bonsor & Bos, 2023). Mach 1 is the speed of sound at a given altitude and anything faster than Mach 5 is considered hypersonic. Mach 5 is 3,800 miles per hour or 6,116 kilometers per hour at sea level (Bonsor & Bos, 2023). There are two primary different types of hypersonic missiles, hypersonic glide vehicles and hypersonic cruise missiles. Hypersonic glide vehicles (HGVs) are boosted early in flight to an altitude and then glide unpowered to their destination. In contrast, hypersonic cruise missiles (HCMs) have engines and are powered throughout their entire flight. In addition to speeds greater than Mach 5, both HGVs and HCMs are highly maneuverable and unpredictable (U.S. GAO, 2019).

Traditional ballistic missiles often reach speeds that are hypersonic. In contrast to traditional ballistic missiles, hypersonic missiles travel at lower altitudes and are significantly more maneuverable within the Earth's atmosphere. Hypersonic threat trajectories are difficult for traditional radars to detect because of these lower altitudes and the curvature of the Earth. (Weinberger, 2023). Figure 1 shows the trajectory of a ballistic missile compared to that of a hypersonic missile and a traditional cruise missile. The cruise missile flies at a much slower speed, allowing additional time for it to be detected by traditional radars and defensive systems. Ballistic missiles fly above the radar horizon, allowing them to be detected and defeated by ballistic missile defenses. In contrast, hypersonic missiles fly at hypersonic speeds and at an altitude that is under radar detection due to the curvature of the Earth.

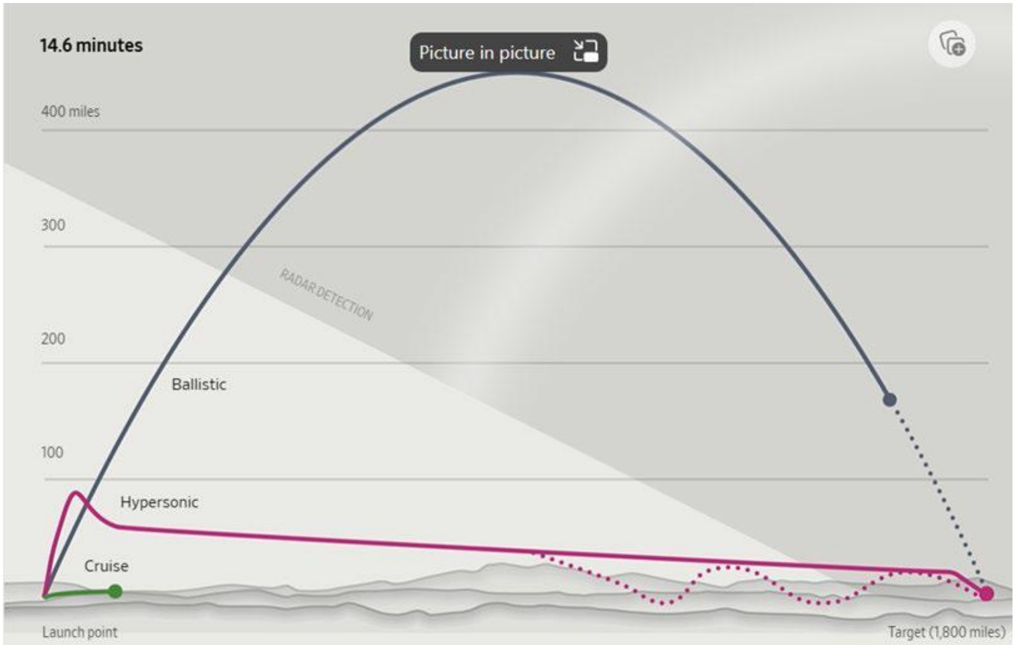

Figure 1. Hypersonic Missile Trajectory compared to Ballistic and Cruise (Weinberger, 2023)

China has been investing heavily in hypersonic missile technology and is considered one of the leading countries in this field. China has developed and tested various types of hypersonic missiles and demonstrated the potential to penetrate existing missile defenses (Hambling, 2024). According to commentary by General John Hyten, USAF (Ret.) on a CBS News broadcast in November 2021, China recently launched a long-range missile that went around the world, dropping off a hypersonic glide vehicle. This test demonstrates that China has the capability to strike anywhere in the United States homeland. One of the missiles that China has been showcasing is the DF-17, which is an air-launched hypersonic missile. The DF-17 can carry both conventional and nuclear payload over long distances. China and Russia are far ahead in their development and fielding of hypersonic missiles. Russia is using hypersonic missiles today against Ukraine.

Congress recognizes this discrepancy in capability from our adversaries and the U.S. lack of defenses, and in the 2019 National Defense Authorization Act (NDAA), required the

"Director of the Missile Defense Agency to produce a report on how hypersonic missile defense can be accelerated to meet emerging hypersonic threats" (Congressional Research Service, 2024, p. 2). Again, in the NDAA for 2024, Congress is weighing in to attempt to force the Missile Defense Agency to accelerate the development of the Glide Phase Intercept program and ensure initial operating capability no later than December 31, 2029 (Hitchens, 2023c). Despite these efforts from Congress, the Glide Phase Intercept program designed to counter hypersonic threats in the glide phase of their flight had an original fielding date in 2028 and now has an estimated fielding date of 2035 (Hitchens, 2023c).

According to the National Defense Strategy released in late 2022, the top priorities for defense are defense of the homeland, deterring strategic attacks against the United States and its allies, deterring aggression while being prepared to prevail in conflict if necessary (U.S. Department of Defense 2022). The National Defense Strategy (NDS) aims to align the top priorities for defense for the DOD and goes on to state that research and development for advanced capabilities such as hypersonic threats will be supported. The NDS prioritizes the space-based sensors that will enable tracking of hypersonic threats. The space-based layer is well on its way to providing the early warning and tracking needed. However, other pieces of the system are well behind this timeline, as they have not been prioritized despite the U.S. making hypersonic defense a top priority and spending billions of dollars. Unfortunately, integrated hypersonic defenses that would include advanced warning, tracking, and interceptors are not expected to materialize this decade. It is anticipated to be the mid-2030s before an integrated capability is fielded to defend against the threats that China and Russia have demonstrated and are using in conflict around the globe today.

Why is Hypersonic Defense Necessary?

The Advancing Threat

Strategic competitors are making long-term investments in offensive hypersonic missiles. The threat to U.S. interests and homeland defense will increase rapidly in quantity, diversity, and sophistication over the next decade. This threat, especially from China and Russia, is outpacing current U.S. efforts to develop and deploy capabilities to deter, defend or defeat hypersonic missiles. Unabated, this trend risks disruptive impacts to U.S. strategy, military operations, and safety. It is allowing U.S. competitors an opportunity to gain a new warfighting advantage and undermine strategic stability at a critical juncture in the Great Power Competition (Sugden, 2022).

Hypersonic missiles highly stress defenses because of a unique combination of high speed (Mach 5 or greater), maneuverability, unpredictability, and diverse trajectories at altitudes between the seams of air & ballistic missile defenses (Karako & Dahlgren, 2022), . China and Russia are developing and deploying multiple dual-capable (conventional/nuclear) hypersonic missile types, with China demonstrating a Fractional Orbit Bombardment System (FOBS) capable of reaching anywhere on Earth with a Hypersonic Glide Vehicle (HGV). North Korea has tested a regional missile with an HGV, and Iran has unveiled two regional missiles it claims are hypersonic (U.S. Department of Defense, 2022). Russia has used hypersonic missiles in the war in Ukraine and is deploying heavy ICBMs armed with HGVs. The quantity, diversity, and sophistication of China’s hypersonic missile arsenal will outpace Russia, making China the most consequential long-term hypersonic threat to U.S. regional interests and homeland defense (DIA, Hypersonic Threat Assessment, 2023).

This advancing threat is allowing U.S. strategic competitors an opportunity to gain a new warfighting advantage. The disruptive impacts of hypersonic threats also risk undermining strategic stability at a critical juncture in Great Power Competition in several ways (Sugden, 2022). First, Russia or China may use hypersonic missiles preceding an intercontinental or theater missile raid to knock out specific U.S. missile defense radars or batteries and reduce U.S. missile defense capabilities, thereby ensuring that follow-on missile launches reach their target. The prospect of Russia or China using hypersonic missiles to complicate or reduce the U.S. missile attack warning assessment and response timeline suggests either competitor might see an opportunity to preemptively decapitate the senior U.S. leadership. Russia or China could use large numbers of hypersonic missiles in deep conventional strikes against U.S. logistics, space-launch, counterspace, C3, intelligence, or war-supporting industrial targets to reduce the U.S. ability to sustain overseas operations and to impose psychological shock on the American public and leadership. Large-scale counter-homeland conventional hypersonic missile strikes by either peer competitor could generate nuclear first-strike incentives between nuclear-armed great powers, thereby undermining crisis stability (Wilkening, 2019).

Advances in strategic competitor's offensive hypersonic missiles could also further undermine strategic stability if those hypersonic weapons are employed with other multi-domain capabilities to reduce senior U.S. leadership decision space in any major conflict with these competitors. The greatest risk is an adversary orchestrating a hypersonic missile attack in conjunction with a counterspace campaign directed against space-based U.S. sensors in GEO orbit. Such an attack risks denying the U.S. critical situational awareness information needed to generate a military response by further reducing or eliminating its warning time of a missile attack against the U.S. Homeland (Sugden, 2022).

Despite the glaring policy discrepancy where there is no COCOM that has tasking to defend the U.S. homeland from hypersonic threats, to be discussed in subsequent sections, and the fact that China has demonstrated the capability to strike anywhere in the U.S., this paper will treat the hypersonic threat as regional to focus defense strategies. Even downgrading the current landscape to a regional threat, the threat to Guam should be paramount. Guam is the westernmost U.S. territory in the Pacific. Guam is home to 170,000 U.S. citizens and nearly 6,500 active U.S. military servicemembers today with plans over the next few years to significantly increase the military presence (Tilghman, 2023). Guam is closer to Beijing than any other U.S. location, and the island plays a critical role for the U.S. Navy supporting the Pacific region, as shown in Figure 2. U.S. Indo-Pacific Command (INDOPACOM) leaders say the island is important for the command's strategy to provide presence, deterrence, and power projection in the region. In May 2022, Navy Admiral John C. Aquilino, Commander of INDOPACOM, testified that "Guam's strategic importance is difficult to overstate" (Aquilino, 2022, p. 13).

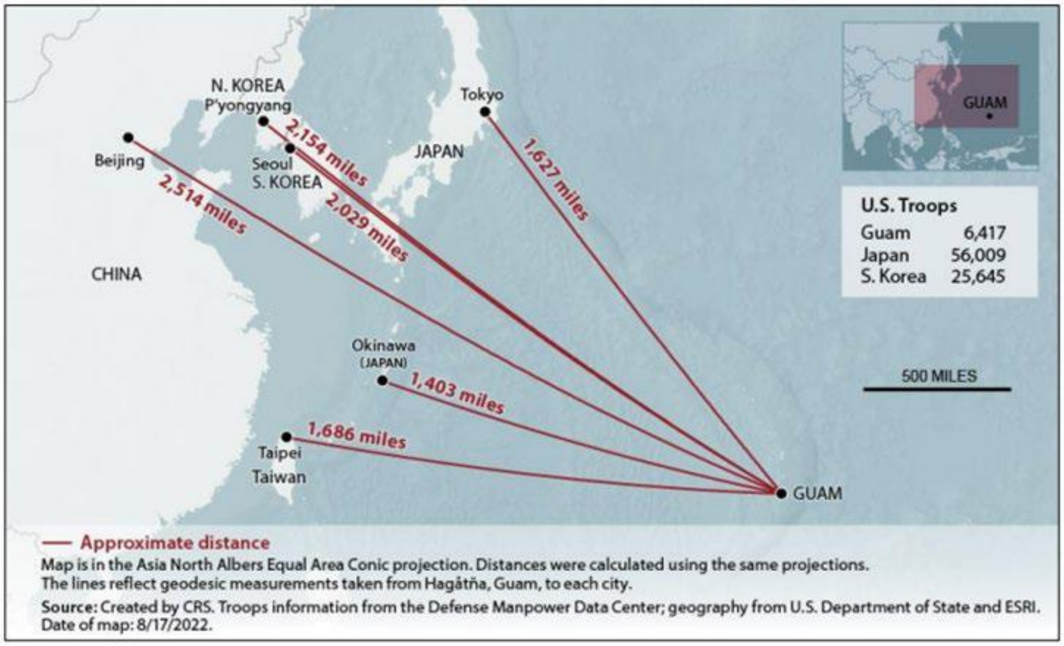

Figure 2. Guam Distances to Major Rim Cities (Tilghman, 2023)

MDA stated back in October of 2022 that Indo-Pacific Command issued new requirements asking for an upgrade to Guam's missile defenses to include "360-degree coverage, and layered defense against regional ballistic, maneuvering ballistic, hypersonic glide, and cruise missile threats" (Tilghman, 2023, p. 17). According to a CRS report to Congress, the Future Years Defense Program (FYDP) contains approximately $9 Billion dollars for Guam's infrastructure and defenses (Tilghman, 2023). This infrastructure is requested to include, in the requirements set forth by INDOPACOM, the ability to defend against hypersonic glide vehicle threats.

Why the U.S. is Falling Behind

Root Causes

The following sections will explore various root causes that are deemed to have impeded the U.S. developing and fielding a fully integrated capability to defend against the increasing aggression from China and other strategic competitors. Today, there is no COCOM that has the tasking to defend the U.S. from hypersonic missile threats. Many senior leaders within the Office of the Secretary of Defense reportedly believe that the U.S. nuclear deterrent capability is sufficient to deter an adversary from launching conventional or nuclear hypersonic missiles against the U.S. homeland or its interests and forces overseas. Moreover, there is a lack of a defined force protection measure against adversary hypersonic offensive missile attacks. These developments are examples of root causes that will be explored. In addition, the U.S. has 1) spent precious resources on numerous duplicative programs, including years of technology development that does not appear to support any future program, 2) lacked an integrated plan among the various agencies charged with developing this capability, and 3) prioritized one piece of the system (space sensors) at the expense of other similarly important pieces of the integrated system needed to defend the U.S. against this growing threat.

Insufficient Domestic Political Consensus

There is a lack of clear consensus between U.S. government stakeholders on the urgency of responding to the hypersonic missile threat. In the FY24 NDAA, the Senate Armed Services Committee stated that the "rapidly growing threat from, and proliferation of, hypersonic missiles is a matter of grave concern" (FY24 NDAA, December 2023, para. 1 under heading: Report on options for accelerating hypersonic missile defenses). The White House does not directly address the hypersonic missile threat in the 2022 National Security Strategy (NSS) (White House, 2022). Department of Defense policy assumes hypersonic weapons "pose an increasing and complex threat," but DOD stated policy is to develop active and passive defenses against "regional" vice regional and homeland hypersonic missile threats (DOD, 2022, p. 2).

This lack of stakeholder consensus is mirrored in nongovernmental narratives on the hypersonic threat. Most government and non-government experts view the hypersonic missile threat as real and growing (Wilkening, 2019). Some nongovernmental experts assert the advantages of hypersonic missiles are exaggerated or false (Wright & Tracy, The Physics and Hype of Hypersonic Missiles, Aug 2021). Others do not acknowledge the threat that hypersonic weapons pose to U.S. Homeland Defense (.Soofer & Costlow, 2023). While this dissonance in assessment continues in both government and nongovernment circles, an unclear priority for the capability to defend against hypersonic threats will persist.

Ineffective Threat Management

U.S. Northern Command (NORTHCOM) is the Combatant Command that is tasked with defense of the U.S. homeland. The number one priority for NORTHCOM is to defend the U.S. homeland, with personnel dedicated 24 hours a day, 7 days a week to defend the U.S. homeland (U.S. Government, n.d.). While the number one mission for NORTHCOM is to protect the U.S., they are currently not tasked to defend the U.S. homeland from hypersonic missile attacks. In a recent speech by Brigadier General Robert David at an MDAA Forum on Hypersonic Defense on February 2, 2024, David stated that NORTHCOM has no tasking against incoming hypersonic missiles and identified this as a major gap area. The tasking to the combatant commanders is stale and does not consider the threats of today, such as the hypersonic threat. If the incoming threat were to fall into the legacy category of a cruise missile, then even if the missile is flying at hypersonic speeds, NORTHCOM would have the task to defend against this threat. However, if the incoming threat is not a cruise missile or a ballistic missile, defense of that hypersonic missile is not tasked to NORTHCOM to be defeated. This is a significant gap in the tasking of the combatant commands and the ability to defend the U.S. homeland. When this gap is pointed out to senior officials within the Office of the Secretary of Defense, they indicate NORTHCOM would treat the incoming hypersonic threat as a nuclear threat and then would have tasking to defeat. The 2022 US Nuclear Posture Review states “The fundamental role of U.S. nuclear weapons is to deter nuclear attack on the United States” (U.S. Department of Defense, 2022a, para. 4). In summary, the current U.S. policy to defeat incoming hypersonic threats to the U.S. homeland is to offensively strike back and to use nuclear weapons and the fear of mutually assured destruction to deter this threat. In a recent speech at an MDAA Forum on Hypersonic Defense on February 2, 2024, Retired U.S. Admiral Mark Montgomery pointed out that it would be possible to defeat every THAAD battery within the U.S. and to kill less than 500 U.S. personnel. The U.S. Nuclear Posture Review goes on to state that “the United States would only consider the use of nuclear weapons in extreme circumstances” (U.S. Department of Defense, 2022a, para. 4). It is incongruent to put the loss of less than 500 U.S. personnel in a category that warrants extreme circumstances and the use of nuclear weapons and assured mutual destruction. The concept of using mutual assured destruction or the fear of massive retaliation to prevent adversaries from attacking the U.S. with conventional weapons is flawed. This concept plays out today in the Red Sea where the attacks are not coming from rational, thinking, or established nuclear powers, but from extremist rebels or terrorist organizations who are not persuaded by fear and who certainly are not rational decision-makers. Nuclear deterrence policies have limited effectiveness against non-state actors who have different motivations and are not historically susceptible to classic threats or fear.

Misaligned Policies Driving Priorities

In addition to ineffective management of the hypersonic threat, relying on outdated or inappropriate nuclear response as a deterrent to a conventional threat attack, there are several other areas of U.S. government policy that have not been aligned to the emergent hypersonic threat. According to the Congressional Research Service report from February 2024, there is apparent disagreement on how hypersonic offensive weapons will be used operationally, which complicates the picture for how to develop a U.S. hypersonic defense capability. Under Mission Requirements for offensive Hypersonic weapons the CRS report states, "Although DOD is funding a number of hypersonic weapons programs…it may not have approved requirements for hypersonic weapons" (Sayler, 2024, p. 22). As a result of this uncertainty, Congress "may seek to obtain information about DOD's evaluation of potential mission sets for hypersonic weapons, a cost analysis of hypersonic weapons and alternative means of executing potential mission sets, and an assessment of the enabling technologies—such as space-based sensors or autonomous command and control systems—that may be required to employ or defend against hypersonic weapons" (Sayler, 2024, p. 22). This lack of agreement on the operational threat of hypersonic weapons has contributed to uncertainty in priority and viability of hypersonic defense capabilities, which has in turn been reflected in limited budgetary expenditures on hypersonic defense and delayed the advancement of hypersonic defense technology. With disagreement on the extent of the hypersonic threat, there has been no policy created placing sufficient priority on defending against that threat, nor has there been sufficient focus on the adversary capability development. Alignment on the operational usage of hypersonic weapons and the extent of the threat to the U.S. and allies would enable policy updates to drive U.S. hypersonic defense priority and develop capability to outpace adversary advancements.

The disagreement on the strategic implications of hypersonic weapons has also caused a strategic-policy disconnect on how to respond in the event of a hypersonic threat attack. The extreme maneuverability of hypersonic weapons relative to other missile systems, such as ICBMs, leads to significant uncertainty in predicted flight path in the event of a hypersonic missile launch, "which could generate uncertainty about the weapon's intended target and therefore heighten the risk of miscalculation or unintended escalation in the event of a conflict" (Sayler, 2024, p. 25). "That unintended escalation could occur as a result of warhead ambiguity, or from the inability to distinguish between a conventionally armed hypersonic weapon and a nuclear-armed one," and "such concerns have previously led Congress to restrict funding for CPS [Conventional Prompt Strike] programs" (Sayler, 2024, p. 25). Dissenting analyst viewpoints on the strategic implications of hypersonic weapons argue that since adversaries such as China and Russia already can strike the U.S. and allies with ICBMs, the addition of hypersonic threats does not change the strategic situation. That viewpoint is summarized in the February 2024 CRS report with statements including "it is really a stretch to try to imagine any regime in the world that would be so suicidal that it would even think threatening to use—not to mention to actually use—hypersonic weapons against the United States...would end well" (Sayler, 2024, p. 26). Unfortunately, that statement treats Hypersonic Weapons usage at the same level as ICBM usage, which overlooks the potential for a more contained, conventional hypersonic threat attack on a smaller strategic target in the U.S. In that situation, with no viable hypersonic defense capability, the only deterrence would be assured mutual destruction, forcing a no-win response decision for the U.S., as discussed in the previous section of this report. For this reason, in "Section 1671 of the FY2021 NDAA (P.L. 116-283) the U.S. Congress directed the Chairman of the Joint Chiefs of Staff, in coordination with the Under Secretary of Defense for Policy, to submit to the congressional defense committees a report that examines 'How escalation risks will be addressed with regards to the use of strategic hypersonic weapons, including whether any risk escalation exercises have been conducted or are planned for the potential use of hypersonic weapons, and an analysis of the escalation risks posed by foreign hypersonic systems that are potentially nuclear and conventional dual-use capable weapons"

(Sayler, 2024, p. 26). That direction has not yet led to any new policy statements regarding escalation risks and changes to strategic response in the event of a hypersonic missile attack, leaving the current policy discussed previously as the only recourse. Until the disagreement on the strategic implications of hypersonic weapons is resolved, this strategic-policy disconnect will persist on how to respond in the event of a hypersonic threat attack.

Beyond the strategic policy misalignments highlighted thus far in this section, another policy shortfall has been the focus on the space sensor layer without corresponding priority placed on the weapon systems being designed to utilize data from that space layer. While the MDA and SDA have been appropriately prioritized to accelerate space-based detection and tracking, including the recent launch of the Hypersonic and Ballistic Tracking Space Sensor (HBTSS) and completion of Tranche 0 for the Proliferated Warfighter Sensor Architecture (PWSA), the only weapon system program of record capable of utilizing data from those sensors remains the Sea-Based Terminal Increment 3 (SBT Inc 3) program fielding in 2025. While that SBT Inc 3 Aegis Weapon System will be the first robust hypersonic defense capability fielded by the United States, its defended area coverage is limited relative to the targeting capabilities of hypersonic threat systems. The MDA’s Glide Phase Intercept (GPI) program is planned to provide layered defense against hypersonic threats, integrating with SBT Inc 3 to extend intercept ranges into the glide phase of a hypersonic threat, but current GPI program of record efforts will not field until many years after the space sensor layer capability is fielded. While policy and corresponding budgets have appropriately prioritized the space sensor layer, the misalignment with defensive weapon systems capable of utilizing the space sensor data will hinder the defensive capabilities and deterrence against hypersonic threats. This misalignment stems from the previously discussed lack of defined mission requirements and priority for hypersonic weapons, which in turn make it “challenging for Congress to evaluate the balance of funding for hypersonic weapons programs, enabling technologies, supporting test infrastructure, and hypersonic missile defense” (Sayler, 2024, p. 24).

In summary for this section, the evaluation of misaligned policies and priorities that have caused the U.S. to fall behind in hypersonic defense are caused by three main drivers. First, the lack of agreement on the operational usage and threat of hypersonic missile systems has contributed to uncertainty in priority and viability of hypersonic defense capabilities. Next, the lack of alignment on a strategic response in the event of a hypersonic threat attack has contributed to uncertainty in the importance and need for developing hypersonic defense systems as a deterrent, as well as raised the risk of conflict escalation since hypersonic threats are inherently ambiguous in targeting and warhead capabilities and not equivalent to other missile systems such as ICBMs. Finally, the established recent policy appropriately prioritizing the space sensor layer to detect and track hypersonic threats has not balanced the defensive weapon system development needed to utilize that space sensor information effectively on equivalent schedules. The next section will evaluate how these policy-related disconnects have influenced budget allocations and contributed to the current state of U.S. hypersonic defense.

Hypersonic Defense Budgetary Analysis

Adversaries of the United States and its allies have demonstrated increasing hypersonic missile capability over numerous test demonstrations in the last 6-7 years and in open conflict in Ukraine. The clear danger of hypersonic threats has been acknowledged by leadership across the Department of Defense, including Gen. Van Herck in his comments to the Senate Armed Services Committee. The Director of the Missile Defense Agency has recognized publicly that the U.S. Navy’s Aegis Sea-Based Terminal defense is the only active defense available to counter hypersonic missiles, with the more robust SBT Increment 3 defense capability not planned for deployment until 2025 and mired in funding alignment difficulties between the MDA and Navy. Given the clarity of the threat and the need for expanded defense capability to ensure protection for the U.S. and its allies, this section will review the priority in budgeting for hypersonic defense over the last several years, investigate how funding has been allocated, determine where investment has been made, evaluate the current state of those investments, and examine the future outlook.

At the highest level, as documented in the United States National Defense Authorization Acts (NDAA) for fiscal years 2021 through 2024, significant allocations have been provided in recent years to hypersonic missile technology research and development. However, much of that funding has been provided for offensive hypersonic missiles, with significantly less funds provided to hypersonic defense initiatives. Vice Admiral Ron Boxall (Ret.) summarized at a recent Missile Defense Advocacy Alliance discussion that "you have to have a defensive system to counter a first mover authoritarian regime like China or Russia, and to do that, we need to be investing similarly in our defensive hypersonics. And right now, the delta is 10 to one, about three and a half billion to 320 million" (MDAA, 2023, para. 12). Reviewing the NDAA validates Admiral Boxall's statement regarding the division of Offensive and Defensive support with the summary of Hypersonic Offensive and Defensive Funding for fiscal years 2021-2024 (FY21-FY24) summarized in Table 1, compiled from the summation of hypersonic offensive and defensive spending in the NDAA Funding Tables for each year (NDAA Funding Tables, FY2021 – FY2024). In addition to the significant imbalance in Hypersonic Offensive funding over Hypersonic Defensive allocations, the total support for Hypersonic Defense has fluctuated as well, from a low of $1.22B in FY21 up to $2.87B in FY20.

Fiscal Year	Offensive Hypersonic Funding	Defensive Hypersonic Funding	Total Hypersonic Technology Funding	Percentage of Defensive to Offensive Hypersonic Funding
2021	$2.51 Billion	$358.9 Million	$2.87 Billion	14.3%
2022	$914.1 Million	$309.8 Million	$1.22 Billion	33.9%
2023	$2.09 Billion	$518 Million	$2.60 Billion	24.8%
2024	$1.54 Billion	$209 Million	$1.75 Billion	13.6%

Table 1. Hypersonic Technology Funding Allocations, FY21 – FY24 (NDAA Funding Tables, FY2021-2024)

While the Defensive Hypersonic Funding (column 3) has been significantly less than Offensive Hypersonic Funding (column 2), a review of how the more challenged defensive funding has been invested is also useful to understand the current state of defensive capabilities. One of the challenges of hypersonic threats is custody of tracking, since terrestrial radar sensors are limited by the radar horizon, with much of the threat's trajectory out of view of these sensors. One avenue to address this challenge is overhead space tracking using a network of satellites, where the U.S. Department of Defense has invested heavily in recent years. This space-based, sensor-layer investment enables engaging weapon systems with the most current track information for a hypersonic threat. Unfortunately, the DOD investment in space-based sensors has not always been aligned and efficient, with the MDA and SDA both pursuing independent efforts, which is discussed in further detail in the next section. The MDA program, called the Hypersonic and Ballistic Tracking Space Sensor (HBTSS), had a budget of $110M in 2022 and launched in early 2024. Meanwhile, the SDA program, called the Proliferated Warfighter Space

Architecture (PWSA), had a successful launch of its Tranche 0 satellites in 2023. These duplicative and misaligned programs drew a rebuke from the Appropriations Subcommittee on Defense in 2022 which stated, “MDA and SDA each launching their own satellites reveals a lack of coordination and cooperation between SDA and MDA, poor oversight on the part of the Department of Defense’s space acquisition enterprise, and waste of taxpayer dollars” (U.S. House of Representatives, 2022, para. 1 under “Launch Strategy for Hypersonic and Ballistic Tracking Space Sensor” heading).

In addition to the inefficient use of funding for the space-based sensor layer, deployment of the next iteration of Sea-Based Terminal capability, SBT Increment 3, has been plagued with delays due to alignment with the U.S. Navy’s Aegis Weapon System development and funding for development activities. As Admiral Hill confirmed, “Aegis SBT is the only active defense available today to counter hypersonic missile threats” (Vergun, 2023, para. 15). In May 2023, however, the MDA announced a two-year delay in the flight testing and certification plan for SBT Increment 3 due to misalignment with the U.S. Navy capability package baseline delivery plan. Per Jason Sherman, “the Navy is planning to add the MDA-developed SBT Inc. 3 capability as part of a bundle of improvements for the aircraft carrier strike group dubbed Aegis Capability Package 2024,” which will not certify until 2025 with the first flight test of a hypersonic glide vehicle, FTM-43, delayed from 2023 until 2025 as well (2023, para. 8). These delays will necessitate continued funding to maintain the program under development and delay robust hypersonic defense capability in the terminal phase of flight by an additional two years, further limiting the ability to defend against these high priority threats.

To summarize this hypersonic defense budgetary analysis, the NDAA funding for the last four fiscal years has included significant spending on hypersonic missile technology.

However, much of that spending has been on offensive capability, not on defensive programs, with less than a quarter of the total funding for FY24 allocated to defensive efforts. With that hypersonic defense limitation, the agencies and services tasked with using that funding efficiently have also struggled significantly to field capability effectively. The MDA and SDA misalignment on HBTSS and the PWSA Tranche 0/1 satellites was one high-profile example of duplicated effort and misused funding. The MDA and Navy's inability to align on plans for fielding of the CP24 baseline that includes SBT Increment 3 robust hypersonic defense capability in the terminal phase has also caused a delay of 2 years to the fielding of that capability. The funding levels and usage of defensive capability development dollars do not align with the priority of hypersonic defense given the demonstrated adversary capability but do reflect the continued disagreement in that priority across the Department of Defense discussed in previous sections.

Space-Based Sensors: An Example of Organizational Inefficiencies

The issue of aligning government roles and responsibilities in the missile defense enterprise to minimize duplication of effort and focus resources on operational solutions currently exists in the development of the future space sensor layer for the Missile Defense System (MDS). Although there have been several attempts to begin a space-based sensor layer, dating back to the Strategic Defense Initiative Organization, it was the Missile Defense Agency (MDA) who conducted the most recent space-tracking demonstration with their Space Tracking and Surveillance System (STSS) program (Lambakis, 2023). Two satellites were launched in 2009 to collect data useful enough for the development of future systems to track objects on a ballistic trajectory (Lambakis, 2023). Yet despite successfully demonstrating the capability, no follow-on program of record ever materialized.

With the emergence of adversary advances in hypersonic missile technologies, Congress, in their fiscal year 2017 (FY17) National Defense Authorization Act (NDAA), designated MDA as the executive agent for hypersonic missile defense. As a holistic hypersonic defense capability depends equally on a portfolio of sensors, interceptors, and battle management platforms, Congress followed up with statutory language in 2017 for MDA to begin development of a "persistent space-based sensor architecture capable of supporting the ballistic missile defense system" (NDAA, 2017, para.1 under "Development of Persistent Space-Based Sensor Architecture" heading). Among the desired functions were for the sensors to produce fire-control-quality tracks of evolving threat missiles, and to be integrated with the other elements of the ballistic missile defense system, to include the command-and-control battle management program, the Terminal High-Altitude Area Defense, Aegis Ballistic Missile Defense, Aegis Ashore, and Patriot Air and Missile Defense systems (NDAA, 2017).

While it was clear at inception that Congress envisioned MDA as being the lead organization to develop the new space layer and integrate it with the existing complement of missile defense capabilities that MDA had played a key role in developing, annual changes to the legislation over the following four years began to erode these intended roles and responsibilities. In 2018, Congress amended their original legislation and added language directing MDA to coordinate with the Air Force Space Command (AFSPC) and U.S. Strategic Command (STRATCOM) to ensure that the new effort was compatible with another space-based sensor development being conducted by the Defense Advanced Research Projects Agency (DARPA) (NDAA, 2018). A change of note from the previous year was that the requested report from MDA regarding the hypersonic defense architecture now also included AFSPC and STRATCOM as signatories. Despite this, Congress appropriated the initial funding of $73 million directly to MDA to begin work on the space sensor activities originally laid out in the FY18 NDAA (U.S. Department of Defense, 2019).

In 2019, Congress continued to make changes to the original space sensor architecture direction to MDA, this time adding details for a “Hypersonic and Ballistic Tracking Space Sensor (HBTSS) Payload” (NDAA, 2019). While MDA was assigned primary responsibility for the development of the HBTSS sensor, Congress directed that the effort be coordinated with the Air Force and the nascent Space Development Agency (SDA), a brand-new organization which had just been created earlier in the year (Erwin, 2019). As SDA’s notional plans were to build out a proliferated constellation of hundreds of satellites for missile tracking and communications in Low Earth Orbit (LEO), the new congressional language was tacitly meant to ensure that all of the stakeholders with overlapping roles and responsibilities were collaborating with each other to develop the future architecture (NDAA, 2019). Funding for the effort continued to go to MDA, as Congress appropriated $108 million for the HBTSS sensor (U.S. Department of Defense, 2020).

The year 2020 represented the first occasion where the conflicting roles and responsibilities for the space sensor architecture began to create political turmoil that went public. Problems began with the release of the President’s Fiscal Year 2021 Budget and the revelation in MDA’s submission that funding responsibility for the continuation of HBTSS was being transferred to SDA and that MDA would no longer be requesting funding for the program (U.S. Department of Defense, 2020). As existing legislation specified that MDA had sole responsibility for developing HBTSS, this budget language attracted unwanted attention from several angry and confused Members of Congress.

During a public March 2020 House Armed Services (HASC) Strategic Forces Subcommittee budget hearing, members lambasted MDA Director, Vice Admiral Hill, over the decision to zero out the HBTSS funding line and give the effort to SDA (Hitchens, 2020). Under questioning, VADM Hill was forced to reveal that it was his boss, the Undersecretary of Defense for Research and Engineering (USD(R&E)), Dr. Michael Griffin, who had concocted the unorthodox arrangement of placing the funding line in SDA's budget submission so that it could then be transferred back to MDA to continue HBTSS development (Hitchens, 2020). Creating further confusion, VADM Hill stated that there was a desire by Dr. Griffin to consolidate all space funding within the SDA and have them play an "architect" role for space development (Hitchens, 2020).

As USD(R&E) oversaw both SDA and MDA at the time, Dr. Griffin had the power to rearrange the funding for budget submission purposes, but in the end, the HASC, along with the rest of Congress, disagreed with this approach and placed the funding back under MDA's purview (NDAA, 2021c). Congress also legislatively re-emphasized in the FY21 NDAA that MDA had sole responsibility for developing HBTSS (NDAA, 2021c). However, they accepted the fact that this payload had to be integrated into the future missile tracking architecture that SDA was developing and directed that a coordinated plan be created and briefed to Congress for how it was going to take place (NDAA, 2021c). A separate section of the FY21 NDAA also directed that SDA be transferred out of the USD(R&E) office and into the U.S. Space Force (USSF), beginning in fiscal year 2022 (NDAA, 2021c).

The seams created by the continuously evolving roles and responsibilities for the space sensor architecture for hypersonic defense were further documented in a June 2022 Government Accountability Office (GAO) report, *Better Oversight and Coordination Needed for Counter-*

Hypersonic Development. The report highlighted the lack of coordination between MDA and SDA over HBTSS and any follow-on space capabilities and brought attention to the fact that the specific authorities between the two were not documented anywhere or even well understood by leadership in the DOD. Of note in the report was the following admission:

> SDA and OUSD(A&S) officials told us that, for several years, the division of labor between MDA and SDA was widely understood as follows: MDA was responsible for developing the HBTSS sensor, and SDA would be responsible for integrating the sensor onto its satellites for operational use. However, this division of labor was never explicitly documented, and subsequent DOD reports have complicated this understanding without confirming or refuting this assignment of responsibilities. (U.S. GAO, 2022, p.31)

The GAO went on to elaborate that while two congressionally directed reports from the USD(R&E) stated that the sensors developed as part of HBTSS would be integrated into SDA's architecture, the reports failed to address which agency would operate the satellites hosting the sensors in future phases. As a result, it was never specified if MDA could "develop (1) sensors for inclusion on SDA satellites, (2) satellites of its own for inclusion in SDA's broader tracking layer, or (3) operate an entirely separate constellation" (U.S. GAO, 2022, p. 32).

Furthermore, while the USD(R&E) reports identified areas where SDA and MDA could collaborate, a planned effort to craft a memorandum of understanding (MOU) to identify roles and responsibilities between the two agencies ended up stalling. The main cause for this was MDA's decision not to equip the optical cross-links necessary for HBTSS to communicate with SDA's satellites on-orbit. MDA officials stated that it was too risky to do so, and they wanted to avoid becoming involved with SDA's plans. However, when GAO asked to see the risk assessment, MDA admitted that there was no documentation available (U.S. GAO, 2022).

Foregoing the optical cross-links prevented a potential demonstration of the detection and cueing process between the SDA wide-field-of-view (WFOV) satellites and the HBTSS sensors. The HBTSS sensors are more sensitive than the sensors that SDA will be deploying and are able to provide "fire control" quality tracks needed for a future interceptor to destroy a hypersonic missile in flight (Hitchens, 2023b). However, there is a trade-off in capabilities, as HBTSS has a narrower view – referred to as medium-field-of view (MFOV) at SDA – and cannot see the wider areas covered by WFOV (Congressional Research Service, 2023). By offloading the communications bridge between the programs, MDA effectively siloed HBTSS into a standalone system and negated any need to agree to a MOU with SDA. Without this MOU, the GAO noted that future space sensor efforts being pursued by each agency run the risk of being duplicative of each other. In the conclusion of their report, the GAO made one of the following recommendations:

> The Secretary of Defense should ensure the Missile Defense Agency, Space Development Agency, Space Force, and any other relevant agencies establish a memorandum of understanding that delineates roles and responsibilities for satellite development and operation in the missile defense and missile warning domains. This memorandum should establish which agencies will develop operational satellites (including prototypes) and articulate a process by which duplication and overlap will be avoided. (U.S. GAO, 2022, p. 36)

Despite the annual changes to legislation and the addition of new and sometimes contradictory direction, MDA completed development of the two HBTSS satellites, and they were launched in February 2024 (Hitchens, 2024). Much like the past failed attempts to stand up follow-on programs of record, a successor to HBTSS has not yet materialized. While GAO stated in their report that MDA had plans to expand HBTSS into an operational constellation and a production program of its own, DOD never requested funding for it (U.S. GAO, 2022). More surprisingly, Congress legislatively curtailed MDA from pursuing any future satellite production programs or associated ground systems in their FY22 NDAA (NDAA, 2021a). This position is quite a contrast when viewed against the original congressional language in 2016 and 2017, which designated MDA as the executive agent for hypersonic missile defense and directed them to begin development activities for both the interceptors and space sensor layer.

At present, SDA is taking over the role of building and deploying space sensors for missile tracking and fire control. After just three years of existence, the agency launched its first missile tracking satellites – dubbed the Tranche 0 Tracking Layer – in 2023 (Erwin, 2023a). Follow-on launches for the Tranche 1 Tracking Layer will take place in 2025 (Hitchens, 2023b). Included within the Tranche 1 baseline are 28 WFOV satellites and 4 MFOV demonstration satellites, which are essentially copies of the HBTSS sensors (Tournear, 2023). These MFOV sensors will demonstrate the cueing capability with the WFOV, which was one of the unachieved objectives of the desired collaboration with MDA. Additional fire control satellites will be launched in the Tranche 2 Tracking Layer, contracts which were awarded in January 2024 for launches in 2027 (Erwin, 2024).

Whether or not SDA was officially directed by DOD leadership to pursue fire control satellites is unclear, but a great unwritten truth in defense acquisitions is that whoever owns the funding controls the narrative. Since its inception in 2019, Congress has appropriated increasingly larger amounts of funding to SDA to pursue their iterative approach to deploying satellites. In fiscal year 2023, Congress added $286 million to the $500 million request for SDA missile tracking, and the FY2024 request jumped to a staggering $1.266 billion (U.S.

Department of the Air Force, 2023). Programs and organizations with these ample resources effectively become the decision makers and have an easier time justifying the solutions that they want to pursue without having to compromise. Another advantage that SDA has is that they only do space acquisitions, and do not have to distribute funding across different types of weapon systems. Although this arrangement focuses resources on a specific scope of work, it highlights a gap in alignment with other weapon system development efforts that will utilize space-based data in an integrated hypersonic defense architecture.

With substantial resources in hand and no official direction, there are some indications that SDA may even be pursuing duplicative efforts within its organization. Not only are fire control satellites being developed within the existing missile tracking tranches, but a separate fire control program, Fire-Control On Orbit-Support-To-The-War Fighter (FOO Fighter or F2) is also being pursued (Hitchens, 2023a). However, as the details of F2 are classified, it is speculative whether it is comparable to MFOV or something else altogether. Nevertheless, much like the GAO warned in its 2022 report, there is clear evidence that the lack of direction and collaboration with others is leading to unnecessary pursuits, duplicative efforts, and inefficient development of an integrated hypersonic defense capability.

Lack of Consolidated Leadership in Missile Defense

The saga of SDA and MDA highlights just one example of the bifurcated roles and responsibilities in the missile defense enterprise. While making decisions at an individual program and agency level is certainly appropriate, it is unfortunate that agencies do not seem willing, or are not being compelled, to work together to produce more holistic and effective solutions. Missile defense consists of many individual pieces that must work together: ground radars, space sensors, interceptors, and battle management. Ownership of these elements is distributed widely across services and agencies, each of which report to separate chains of command and have their own requirements, authorities, funding, and bureaucratic challenges to overcome to gain advocacy and for their programs.

Recognizing this, Congress, in the FY22 NDAA, directed the Secretary of Defense to enter into a contract with the National Academy of Public Administration (NAPA) to “carry out a study regarding the roles and responsibilities of the various components of the Department of Defense as they pertain to missile defense” (NDAA, 2021b, Sec. 1675(a)(2)(A)). Not only was the study to take a comprehensive look at the entire missile defense enterprise, but it was to identify “gaps in component capability of each applicability component for performing its assigned missile defense roles and responsibilities” and “opportunities for deconflicting mission sets, eliminating areas of unnecessary duplication, reducing waste, and improving efficiency across the full range of missile defense activities” (NDAA, 2021c, Sec. 1675(a)(2)(B)(iii)). Recommendations for legislative action and timetables for implementation of opportunities were also directed.

In May 2023, NAPA released their report, *Integration of Missile Defense*. Chief among their findings was a familiar refrain from the GAO report the year prior: “The lack of clarity around roles and responsibilities in the integrated missile defense enterprise produces confusion over ownership, funding responsibilities, and accountability for progress toward meeting enterprise objectives” (Kodat et al., 2023, p. 8).

Another key finding centered around the fact that there is no missile defense integrator with the necessary authorities and budget to acquire the needed capabilities for missile defense (Kodat et al., 2023). As a result, the report concluded the following:

- Acquisition authorities are fragmented across the multiple components with missile defense responsibilities;
- Not all components with missile defense acquisition responsibilities have the flexibilities MDA is afforded;
- There is no effective top-down technical authority to achieve joint interoperability;
- The complicated organizational structure creates seams that can be difficult to work across;
- CCMDs and Services do not always have the ability to provide early and consistent input to requirements development and acquisition;
- The Services are not incentivized to prioritize integrated missile defense; and
- No one is responsible for setting enterprise-wide investment priorities based on a global, integrated view of missile defense. (Kodat et al., 2023, pp. 68-69)

"This situation causes confusion; slows decision making, acquisition of capabilities, and innovation; and increases the potential for gaps, seams, and unnecessary duplication" (Kodat et al., p. 69).

Among the recommendations that NAPA put forward were for 1) the Deputy Secretary of Defense, or the component designated as missile defense integrator, to regularly document missile defense roles and responsibilities; and 2) have the Deputy Secretary of Defense designate an existing organization or create a new one to serve as an enterprise-level missile defense integrator (Kodat et al., 2023). The report went on to identify several key elements that the missile defense integrator should have, including requirements generation, acquisition and technical authority, and proximity to senior civilian leaders who could make timely decisions and facilitate coordination across the disparate stakeholders. To give this position the sufficient weight it needed, the report recommended that the integrator should be a 4-star officer (Kodat et al., 2023).

Whether or not Congress will legislatively create a missile defense integrator in a future NDAA remains to be seen, but one indication that they are taking this seriously is that they included language in the FY24 NDAA prohibiting 50% of funds to be obligated and expended for the Office of Cost Assessment and Program Evaluation (CAPE) until the Secretary of Defense provides a response to the NAPA report (NDAA, 2023). Pending the timely submission of the Secretary's response, Congress may be able to legislatively create the integrator position within the FY25 NDAA. This augmentation is a needed addition, as the missile defense enterprise will continue to struggle until a leader can exert some control over the disparate entities.

Solutions to Fielding Hypersonic

Defense Raise Awareness of the Growing Threat

Building a broader national understanding of the hypersonic threat will lead to greater acceptance of acquisition risk and greater understanding and acceptance of expenditures on technological investments that might fail in the short-term but ultimately lead to innovation needed to meet the long-term term hypersonic missile threat. Toward this end, the intelligence community should be tasked with preparing an annual unclassified report on foreign hypersonic threat trends, including a classified annex. To the extent possible, discussions about acquisition risk in developing hypersonic defenses and the risks associated with failure to keep pace with the rapidly advancing hypersonic threat should be held in public. (Kodat et al., 2023) Over the near-term, public Congressional hearings should be held and widely publicized via C-Span and other media forums. Authoritative experts from governmental and non-governmental institutions should provide oral testimony to the appropriate Congressional committees, and their written formal testimony and answers to questions during the hearing should be publicly available. Senior leaders should be required to attend war games and other exercises. It seems that too often senior leaders do not attend these types of events and have a lack of awareness of the dire outcomes and only receive summary reports of the exercises that often gloss over the real issues or challenges faced during the war games. Improving the awareness of senior leaders and the American public of the imminent threat of hypersonic weapons will also help align the priority of a defense capability against these threats and sustain a demand to outpace adversary development.

Establish A Commander's Intent and Adjust Risk Tolerance

According to the Thayer model of leadership, a well-known and proven model used at prestigious institutions such as the United States Military Academy at West Point, a leader must establish a commander's intent. This vision is intended to align the entire population with what is important and what we are attempting to do. A great example of establishing a commander's intent is the famous 1961 Address at Rice University on the Nation's Space Effort that President Kennedy gave stating that "We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard" (Kennedy, 1961, 9:03). Kennedy's speech urged Congress to provide the resources necessary to support the goal of putting a man on the moon by the end of the decade and bringing him home safely. It provided the commander's intent that aligned everyone supporting the effort and ensured the goal was clear. Like the crisis in 1961, the U.S. faces a crisis today with the growing aggressions from China and other strategic competitors. A clear commander's intent is needed to align all the various services, agencies, and industry patterns toward a goal of establishing an integrated hypersonic defense by the end of the decade. Once the commander's intent is established, other guiding documents such as the NDS and MDR will need to be updated to align with the intent to flow down guidance across the DOD.

The National Defense Strategy acknowledges that the current acquisition "system is too slow and too focused on acquiring systems not designed to address the most critical challenges we now face" (U.S. Department of Defense, 2022b, p. 19). The NDS states a strategy that will "reward rapid experimentation, acquisition and fielding" is needed to achieve the goals of the NDS (U.S. Department of Defense, 2022b, p. 19). Currently, the length of time to develop and field a new system is nearly a decade. For example, Standard Missile 6 acquisition was approved in 2004, and the program did not achieve initial operational capability until 2013. (Missile Defense Project, 2023). A requirement for hypersonic defense was established in 2017, and the current timeline for fielding of the GPI program is 2035, nearly two decades after a need was established. This timeline is insufficient to keep pace with strategic competitors, defend the U.S. homeland, and defend U.S. and allied militaries. The lessons of history were the focus of a recent speech by General (Ret) Hyten where he spoke about the canceled DARPA Hypersonic Test Vehicle program that experienced two flight failures in the 2007 timeframe and was canceled. These failures resulted in over two years of root cause, cancellation of a program, rewickering of acquisition, and a repeat program many years later. This result is a loss of several years in development, and it ultimately has allowed adversaries to get ahead of the U.S. capability. Hyten also talked about the Discover program that finally put Discover 13 into space, after 18 months of continual failures on Discover 1 through 12 (Hyten, 2024). Another example of accelerated learning through failure can be pulled from the Soviet Union's desire to establish

IAMD (Gruntman, 2023). According to *Psychology Today*, humans learn better from failure than from success (Atanasiu, 2023). Cambridge University, along with Australian University are studying and documenting the benefits of failure in learning, and their research indicates that failure as an essential tool in innovation (Sweaney, 2023). The DOD must adopt different policies toward failure to allow innovation and for capability to be delivered in a much timelier manner to the warfighter. The commander's intent shall contain and document the desire to decrease fielding times with failure learning and not penalize programs, agencies, or industry for failures along the path to delivering capability.

Appoint a Single System Integrator

As highlighted in several sections of this report, organizational inefficiencies and a lack of coherent alignment in the priority and policy for hypersonic defense have thus far hindered advancement of U.S. hypersonic defense capabilities. To address some of those hindrances, it is recommended that a single system integrator be identified for all hypersonic defense development inclusive of sensors, command and control, weapon systems, and effectors. The challenge of hypersonic defense requires coordination across many different areas, but as evidenced by the HBTSS and PWSA examples, as well as the misalignments in priority and schedule between the space sensor layer and Glide Phase Intercept program, an overall management structure for the hypersonic defense enterprise is necessary to both align development and drive out inefficiencies.

While multiple organizations, companies, and other contributors will undoubtedly be necessary to field a successful hypersonic defense system, the benefit of a centralized system integrator is having a single point of ownership and responsibility, driving decisions and alignment across the enterprise. This approach would streamline coordination among the different subsystems, ensuring efficient communication and a clear delineation of roles and responsibilities. Instead of MDA and SDA developing parallel space sensor solutions, an overall system integrator would be responsible for all space sensor development activity, as a subcomponent of the overall hypersonic defense system, and it could both oversee and provide direction to separate agencies and services developing related capabilities. This structure would also be helpful across the military services by enabling cross-pollination of land-based, sea-based, air-based, and space-based potential hypersonic defensive capabilities. In addition, a common system integrator could drive consistent standards and processes across the hypersonic defense development enterprise. This integration would prevent the proliferation of different, disparate standards that could contribute to inefficient design and deployment of future hypersonic capabilities. Finally, the system integrator would be responsible for budgetary decisions and allocations as well, to better align the budget provided by Congress to balance, for example, offensive and defensive hypersonic capabilities, or sensor and effector development.

An example of this system integrator role exists today with the Ballistic Missile Defense System (BMDS), where the MDA executes overall responsibility for all subcomponents of the BMDS. This perspective may be extensible to a hypersonic defense system as well, but the system integrator role could also be allocated elsewhere as long as those responsibilities were clearly defined and allocated appropriately. The goal of establishing this role would be to create a holistic view of hypersonic defense, define roles and responsibilities for development, and align schedules, budgets, and capability deployments. While progress has been made in fits and starts under the current structures for hypersonic defense, a lead system integrator role is critical to more efficiently develop the hypersonic defense enterprise moving forward.

Embrace an Iterative Capability and a Higher Risk Tolerance

The practice of spending several years in development to create zero-defect, technologically sophisticated weapons platforms is a Cold War relic that is no longer suitable for 21st century Great Power Competition. To stay ahead of its adversaries, the United States must eschew its antiquated acquisition practices and move to rapidly field modern capabilities that can be repeated over shorter periods of time. To match this accelerated pace, DOD must also accept a higher degree of risk in testing and operational use.

The Space Development Agency is the current champion of this approach, as they are building a proliferated architecture of missile tracking and communications satellites and launching them in tranches every two years. This shift represents a radical change from the traditional 7-to-10-year development cycles of most major space programs. By deploying minimum viable products over shorter periods of time, the warfighter will get capabilities faster and will not have to wait years to receive platforms that are already obsolete by the time they are delivered. In essence, SDA is implementing the tenets of software development - where applications receive continuous updates - and adapting it for hardware.

This approach has already generated positive attention in defense circles, with the Atlantic Council's *Commission on Defense Innovation Adoption* recommending that additional DOD organizations adopt the SDA model (McNamara et al, 2024). Specifically, they state that DOD should look at current technologies from the labs and industry that can quickly be fielded and scaled within existing rapid acquisition authorities, and target capability areas where the current operational model no longer applies (McNamara et al, 2024). To accelerate missile defense technologies to meet the existing and evolving threats, it will be paramount to use this type of approach.

Conclusion

Strategic competitors are rapidly improving their offensive hypersonic missile capabilities, and these advances pose a direct and sustained threat to the security of the United States and the safety of the American people. This current threat, especially from China and Russia, is a risk to the regional defense of U.S. forces, bases, allies, and interests overseas as well as the defense of the U.S. homeland, including Guam and continental United States. The quantity, diversity, and sophistication of this threat will increase substantially over the next decade, and this trend is clearly outpacing current U.S. efforts to develop and deploy capabilities to deter, defend, or defeat hypersonic missiles. In particular, China is the most consequential long-term hypersonic threat to U.S. regional interests and homeland defense.

Unabated, this trend line risks disruptive impacts on U.S. strategy, military operations, and safety. It is allowing U.S. competitors an opportunity to gain a new warfighting advantage and to undermine strategic stability at a critical juncture in Great Power Competition. The primary finding of our report is that the U.S. is being outpaced in a competitive balance with foreign offensive hypersonic missiles due to a combination of domestic-based political, organizational, policy, and strategic factors. This predicament is not due to an inability to develop and field technologies and capabilities necessary to mount effective hypersonic missile defenses. The key to the United States effectively pivoting toward this threat and ultimately outpacing and gaining a comparative advantage in countering the hypersonic missile threat is to implement the solutions identified in this report. These solutions are long overdue, and the time to act is now.

References

Atanasiu, R. (2023, September 28). *What exactly do we learn from failure?* Psychology Today. https://www.psychologytoday.com/us/blog/to-choose-or-not-to-choose/202309/what-exactly-do-we-learn-from-failure

Bonsor, K., & Bos, S. (2023, September 27). *Hypersonic speed explained: How hypersonic planes work*. HowStuffWorks Science. https://science.howstuffworks.com/transport/flight/modern/hypersonic-plane.htm

Congress. (2018, May 15). National Defense Authorization Act for Fiscal Year 2019 REPORT. Congress.com. https://www.congress.gov/115/crpt/hrpt676/CRPT-115hrpt676.pdf

Congressional Budget Office. (February, 2021). National Cruise Missile Defense: Issues and Alternatives. Retrieved from Congressional Budget Office: https://www.cbo.gov/system/files/2021-02/56950-CMD.pdf

Congressional Research Service. (2021, July 16). Conventional Prompt Global Strike and Long-Range Ballistic Missiles: Background and Issues. Retrieved from Congressional Research Service: https://crsreports.congress.gov/product/pdf/R/R41464/52

Congressional Research Service. (2023, August 21). Hypersonic Missile Defense: Issues for Congress. Retrieved from Congressional Research Service: https://crsreports.congress.gov/product/pdf/IF/IF11623

Congressional Research Service. (2024, February 9). Hypersonic Weapons: Background and Issues for Congress. Retrieved from Congressional Research Service: https://crsreports.congress.gov/product/pdf/R/R45811/38

Defense Intelligence Agency (DIA). (2023, March 2). Hypersonic Threat Assessment https://democrats-armedservices.house.gov/_cache/files/3/5/35e5f6c5-cffd-4d99-b4bc-9bed335dca4b/6185535D1E4EE6CDDD36142EC501C91B.freisthler-statement.pdf

DOD Directive 7045.20. (2023, September 25). Capability Portfolio Management. https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodd/704520p.pdf?ver=Y_7TIls2RHyUIYVGHOH6iA%3D%3D

Erwin, S. (2019, March 13). *Shanahan officially establishes the Space Development Agency*. Retrieved from Space News: https://spacenews.com/shanahan-officially-establishes-the-space-development-agency/

Erwin, S. (2023a, April 2). *SpaceX launches 10 satellites for U.S. Space Development Agency*. Retrieved from Space News: https://spacenews.com/spacex-launches-10-satellites-for-u-s-space-development-agency/

Erwin, S. (2023b, December 28). *Pentagon agencies team up in upcoming launch of hypersonic tracking satellites*. Retrieved from Space News: https://spacenews.com/pentagon-agencies-team-up-in-upcoming-launch-of-hypersonic-tracking-satellites/

Erwin, S. (2024, January 16). *Space Development Agency awards contracts worth $2.5 billion for missile-tracking satellites*. Retrieved from Space News: https://spacenews.com/space-development-agency-awards-contracts-worth-2-5-billion-for-missile-tracking-satellites/

February 2024 hypersonic missile defense forum. Missile Defense Advocacy Alliance. (2024, February 2). https://missiledefenseadvocacy.org/advocacy/events/conferences/february-2024-hypersonic-missile-defense-forum/

Gruntman, M. (2023, September). *Intercept 1961: From the First Intercept of a Long Range Ballistic Missile to Soviet Missile and Space Defense*. USC SHIELD. Los Angeles; California.

Hambling, D. (2024, January 9). *Hypersonic missiles: The 13 most terrifying missiles in the world*. Popular Mechanics. https://www.popularmechanics.com/military/a42386379/hypersonic-missiles-arms-race/

Han, E. (2023). Root cause analysis: What is it and how do perfect one. Harvard Business School Online. https://online.hbs.edu/blog/post/root-cause-analysis

Harper, J. (2021, April 21). *Government to Shell out $15 Billion for Hypersonics.* https://www.nationaldefensemagazine.org/articles/2021/4/21/government-to-shell-out-15-billion-for-hypersonics#:~:text=Between%20fiscal%20years%202015%20and%202024%2C%20federal%20agencies,technologies%2C%20according%20to%20projections%20by%20a%20watchdog%20group.

Hitchens, T. (2020, March 12). *HASC Grills MDA Chief On '21 Budget, Space-Based Sensors*. Retrieved from Breaking Defense: https://breakingdefense.com/2020/03/hasc-grills-mda-chief-on-21-budget-space-based-sensors/

Hitchens, T. (2023a, July 14). *There goes my missile: SDA eyes new FOO Fighter missile defense 'fire control' sats*. Retrieved from Breaking Defense: https://breakingdefense.com/2023/07/there-goes-my-missile-sda-eyes-new-foo-fighter-missile-defense-fire-control-sats/

Hitchens, T. (2023b, May 11). *Congressional concern re-emerges on fate of MDA's hypersonic missile tracking sensors*. Retrieved from Breaking Defense: https://breakingdefense.com/2023/05/congressional-concern-re-emerges-on-fate-of-mdas-hypersonic-missile-tracking-sensors/

Hitchens, T. (2023c, April 28). *DOD approves next step for GPI to defend against hypersonic missiles*. Breaking Defense. https://breakingdefense.com/2023/04/dod-approves-next-step-for-gpi-to-defend-against-hypersonic-missiles/

Hitchens, T. (2023d, June 12). *Draft house defense policy bill would speed hypersonic missile defense interceptor*. Breaking Defense. https://breakingdefense.com/2023/06/draft-house-defense-policy-bill-would-speed-hypersonic-missile-defense-interceptor/

Hitchens, T. (2024, February 15). *SDA, MDA missile tracking demonstration payloads blast off*. Breaking Defense. https://breakingdefense.com/2024/02/sda-mda-missile-tracking-demonstration-payloads-blast-off/

Hudson Institute. (2019, February 6). The 2019 U.S. Missile Defense Review: A Conversation with Under Secretary John C. Rood. Washington D.C. https://s3.amazonaws.com/media.hudson.org/files/publications/Transcript_John_Rood_US_Missile_Defense_Review.pdf

Hyten, J. (2024, February 2). Transcript from Presentation at the MDAA sponsored Hypersonic Missile Defense Forum, 2 February 2024. https://missiledefenseadvocacy.org/advocacy/events/conferences/february-2024-hypersonic-missile-defense-forum/

Karako, T., & Dahlgren, M. (2022, February 7). *Complex Air Defense: Countering the Hypersonic Missile Threat*. CSIS. https://www.csis.org/analysis/complex-air-defense-countering-hypersonic-missile-threat

Kennedy, J. F. (1961, September 12). Address at Rice University on the Nation's Space Effort. (18:27). https://www.jfklibrary.org/learn/about-jfk/historic-speeches/address-at-rice-university-on-the-nations-space-effort

Kodat, R., Hardy, K., Rapuano, M., Tucker, J., Higgins, J., & Johnson, E. (2023, May 30). *Integration of Missile Defense*. Retrieved from National Academy of Public Administration: https://s3.us-west-2.amazonaws.com/napa-2021/NAPA-Integration-of-Missile-Defense-Final-Report.pdf

Lambakis, S. (2021, October 12). *Missile Defense and the Space Arena*. Retrieved from National Institute for Public Policy: https://nipp.org/wp-content/uploads/2021/10/IS-504.pdf

Lambakis, S. (2023, August). *Space Sensors and Missile Defense*. Retrieved from National Institute for Public Policy: https://nipp.org/monographs_cpt/space-sensors-and-missile-defense/

Mackenzie, D. A. (1990). *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance*. MIT Press.

Marlowe, M. (2020, April 8). *Three obstacles are slowing space sensors for hypersonic threats*. Retrieved from Defense News: https://www.defensenews.com/space/2020/04/08/three-obstacles-are-slowing-space-sensors-for-hypersonic-threats/

McNamara, W. M., Modigliani, P., MacGregor, M., & Lofgren, E. (2024). *Commission on Defense Innovation Adoption: Final Report*. Atlantic Council. https://www.atlanticcouncil.org/in-depth-research-reports/report/atlantic-council-commission-on-defense-innovation-adoption/

MDAA. (2023, November 22). "Validation of Our Best Missile Defense Capability." https://missiledefenseadvocacy.org/alert/validation-of-our-best-missile-defense-capability/

Missile Defense Project. (2023). "Standard Missile-6 (SM-6)," *Missile Threat*, Center for Strategic and International Studies, April 14, 2016, last modified March 7, 2023. https://missilethreat.csis.org/defsys/sm-6/

NDAA. (2016). National Defense Authorization Act for Fiscal Year 2017, Pub. L. No. 114-328, §1687, (Dec. 23, 2016), 130 Stat. 2629. Retrieved from United States Code: https://uscode.house.gov/statviewer.htm?volume=130&page=2629

NDAA. (2017). National Defense Authorization Act for Fiscal Year 2018, Pub. L. No. 115-91, §1683, (Dec. 12, 2017), 131 Stat. 1777. Retrieved from United States Code: https://uscode.house.gov/statviewer.htm?volume=131&page=1777

NDAA. (2018). National Defense Authorization Act for Fiscal Year 2019, Pub. L. No. 115-232, §1675(a)–(c), (d)(2), (Aug. 13, 2018), 132 Stat. 2159, 2160. Retrieved from United States Code: https://uscode.house.gov/statviewer.htm?volume=132&page=2159

NDAA. (2019). National Defense Authorization Act for Fiscal Year 2020, Pub. L. No. 116-92, §1683, (Dec. 20, 2019), 133 Stat. 1782. Retrieved from United States Code: https://uscode.house.gov/statviewer.htm?volume=133&page=1782

NDAA. (2021a). National Defense Authorization Act for Fiscal Year 2022, Pub. L. No. 117-81, §1662(b)(1), (Dec. 27, 2021), 135 Stat. 2103. Retrieved from United States Code: https://uscode.house.gov/statviewer.htm?volume=135&page=2103

NDAA. (2021b). National Defense Authorization Act for Fiscal Year 2022, Pub. L. No. 117-81, §1675(a)(2)(A), (Dec 27, 2021), 135 Stat. 2116. Retrieved from United States Code: https://uscode.house.gov/statviewer.htm?volume=135&page=2116#

NDAA. (2021c). National Defense Authorization Act for Fiscal Year 2022, Pub. L. No. 117-81, §1675(a)(2)(B)(iii), (Dec 27, 2021), 135 Stat. 2116. Retrieved from United States Code: https://uscode.house.gov/statviewer.htm?volume=135&page=2116#

NDAA. (2021d). National Defense Authorizations Act Funding Tables for 2021. https://www.armed-services.senate.gov/imo/media/doc/S4049%20-%20FY%202021%20NDAA%20Funding%20tables.pdf

NDAA. (2021e). National Defense Authorization Act for Fiscal Year 2021, Pub. L. No. 116-283, §1645(h), formerly §1645(g), (Jan. 1, 2021), 134 Stat. 4064, renumbered §1645(h). Retrieved from United States Code: https://uscode.house.gov/statviewer.htm?volume=134&page=4064

NDAA. (2022). National Defense Authorizations Act Funding Tables for 2022. https://www.armed-services.senate.gov/imo/media/doc/FY22%20Funding%20Tables.pdf

NDAA. (2023). National Defense Authorization Act for Fiscal Year 2024, Pub. L. No. 118-31, §1668, (Dec. 22, 2023), https://www.congress.gov/bill/118th-congress/house-bill/2670

NDAA. (2023). National Defense Authorizations Act Funding Tables for 2023. https://www.armed-services.senate.gov/imo/media/doc/fy23_ndaa_funding_tables.pdf

NDAA. (2024). National Defense Authorizations Act Funding Tables for 2024. https://www.armed-services.senate.gov/imo/media/doc/fy24_ndaa_funding_tables.pdf

OUSD. (2022, February 9) Acquisition & Sustainment Annual Report, 2021. https://www.acq.osd.mil/resources/acq/docs/2021-AS-Annual-Report-FINAL.pdf

Sayler, K. M. (2024, February 9). Hypersonic Weapons: Background and Issues for Congress – CRS Reports. https://crsreports.congress.gov/product/pdf/R/R45811/38

Sherman, J. (2023, May 17). DOD delays by two years maiden intercept attempt of hypersonic glide vehicle target. *Inside Defense*. https://insidedefense.com/daily-news/dod-delays-two-years-maiden-intercept-attempt-hypersonic-glide-vehicle-target

Soofer, R., & Costlow, M. (2023, November 15). *US homeland missile defense: Room for expanded roles*. Atlantic Council. https://www.atlanticcouncil.org/in-depth-research-reports/issue-brief/us-homeland-missile-defense-room-for-expanded-roles/

Statement of Adm. John C. Aquilino, U.S. Navy Commander, U.S. Indo-Pacific Command, before the House Committee on Appropriations Subcommittee on Defense, U.S. Indo-Pacific Command Posture, May 17, 2022, p. 13, at https://docs.house.gov/meetings/AP/AP02/20220517/114752/HHRG-117-AP02-Wstate-AquilinoJ-20220517.pdf

Stone, C. (2022, June). *Orbital Vigilance: The Need for Enhanced Space-Based Missile Warning and Tracking*. Retrieved from Mitchell Institute for Aerospace Studies: https://mitchellaerospacepower.org/wp-content/uploads/2022/06/Space_Based_Early_Warning_Policy_Paper_36-FINAL.pdf

Sugden, B. (2022). Analyzing the Potential Disruptive Effects of Hypersonic Missiles on Strategy and Joint Warfighting. *Joint Forces Quarterly, Issue 104*, 1st Quarter 2022 (pp. 6-21). https://ndupress.ndu.edu/Portals/68/Documents/jfq/jfq-104/jfq-104.pdf

Sweaney, N. (2023, April). *The power of failure: Fostering Resilience and creativity in academia, a case study with research students*.
https://teaching.weblogs.anu.edu.au/2023/04/05/the-power-of-failure-fostering-resilience-and-creativity-in-academia-a-case-study-with-research-students/

Tilghman, A. (2023, August 3). Guam: Defense Infrastructure and Readiness - CRS Reports. https://crsreports.congress.gov/product/pdf/R/R47643

Tournear, D. (2023). 2nd Annual Spacepower Security Forum 2023 (Speech transcript). Mitchell Institute. https://mitchellaerospacepower.org/wp-content/uploads/2023/04/SSF-2023-_-Lunch-Keynote_-Dr.-Derek-Tournear-Director-SDA.pdf

U.S. Congress. (2021). National Defense Authorization Act for Fiscal Year 2022. S. 2792—117th Congress (2021-2022). https://www.congress.gov/bill/117th-congress/senate-bill/2792/text

U.S. Department of Defense. (2019, March). Department of Defense Fiscal Year (FY) 2020 Budget Estimates: Missile Defense Agency Research, Development, Test & Evaluation, Defense-Wide. Retrieved from https://comptroller.defense.gov/Portals/45/Documents/defbudget/fy2020/budget_justification/pdfs/03_RDT_and_E/RDTE_Vol2_MDA%20RDTE_PB20_Justification_Book.pdf

U.S. Department of Defense. (2020, February). Department of Defense Fiscal Year (FY) 2021 Budget Estimates: Missile Defense Agency Research, Development, Test & Evaluation, Defense-Wide. Retrieved from https://comptroller.defense.gov/Portals/45/Documents/defbudget/fy2021/budget_justification/pdfs/03_RDT_and_E/RDTE_Vol2_MDA_RDTE_PB21_Justification_Book.pdf

U.S. Department of Defense. (2022a). Fact sheet: 2022 nuclear posture review and missile defense review. https://media.defense.gov/2022/mar/29/2002965339/-1/-1/1/fact-sheet-2022-nuclear-posture-review-and-missile-defense-review.pdf

U.S. Department of Defense (2022b). National Defense Strategy (comprising the 2022 Nuclear Posture Review and the 2022 Missile Defense Review, dated 27 October 2022).

https://media.defense.gov/2022/oct/27/2003103845/-1/-1/1/2022-national-defense-strategy-npr-mdr.pdf

U.S. Department of Defense. (2023, March). Department of Defense Fiscal Year (FY) 2024 Budget Estimates: Missile Defense Agency Research, Development, Test & Evaluation, Defense-Wide. Retrieved from https://comptroller.defense.gov/Portals/45/Documents/defbudget/fy2024/budget_justification/pdfs/03_RDT_and_E/RDTE_Vol2_MDA_RDTE_PB24_Justification_Book.pdf

U.S. Department of the Air Force. (2023, March). Department of Defense Fiscal Year (FY) 2024 Budget Estimates: Air Force Research, Development, Test & Evaluation, Space Force. Retrieved from https://www.saffm.hq.af.mil/Portals/84/documents/FY24/Research%20and%20Development%20Test%20and%20Evaluation/FY24%20Space%20Force%20Research%20and%20Development%20Test%20and%20Evaluation.pdf?ver=BQWN2ms9

U.S. Government Accountability Office (U.S. GAO). (2019, October 3). Science & Tech Spotlight: Hypersonic Weapons. https://www.gao.gov/products/gao-19-705sp?utm_source=blog&utm_medium=social&utm_campaign=watchblog

U.S. Government Accountability Office (U.S. GAO). (2021, March). Hypersonic Weapons: DOD Should Clarify Roles and Responsibilities to Ensure Coordination Across Development Efforts. https://www.gao.gov/assets/720/713180.pdf

U.S. Government Accountability Office (U.S. GAO). (2022, June 16). *Missile Defense: Better Oversight and Coordination Needed for Counter- Hypersonic Development*. Retrieved from Government Accountability Office: https://www.gao.gov/products/gao-22-105075

U.S. Government Accountability Office (U.S. GAO). (2023, May). *Missile Defense: Annual Goals Unmet for Deliveries and Testing*. Retrieved from Government Accountability Office: https://www.gao.gov/assets/gao-23-106011.pdf

U.S. Government. (n.d.). Homeland defense. Northern Command. https://www.northcom.mil/HomelandDefense/

U.S. House of Representatives. (2022, March 9). Congressional Record Vol. 168, No. 42. https://www.congress.gov/congressional-record/volume-168/issue-42/house-section/article/H1709-1

Venckunas, V., Stankeviciute, E., & Charpentreau, C. (2021, March 24). *US is spending $15B on hypersonic weapons, report reveals*. AeroTime. https://www.aerotime.aero/articles/27526-US-is-spending-15B-on-hypersonic-weapons-report-reveals

Vergun, D. (2023, May 10). *General Says Countering Hypersonic Weapons Is Imperative*. https://www.defense.gov/News/News-Stories/Article/Article/3391322/general-says-countering-hypersonic-weapons-is-imperative/

Weinberger, S. (2023, September 18). Hypersonic missiles are game-changers, and America doesn't have them. *The Wall Street Journal*. https://www.wsj.com/politics/national-security/hypersonic-missiles-america-military-behind-936a3128

Widdowson, M. (2011). Case Study Research Methodology. *International Journal of Transactional Analysis Research 2*(1). https://ijtarp.org/article/view/17055/10970

Wilkening, D. (2019). Hypersonic Weapons and Strategic Stability. *Survival (London), 61*(5), 129–148. https://doi.org/10.1080/00396338.2019.1662125

Wright, D., & Tracy, C. (2021, August 1). *The physics and hype of Hypersonic Weapons*. Scientific American. https://www.scientificamerican.com/article/the-physics-and-hype-of-hypersonic-weapons/