**Irresponsible Innovation and U.S. Hypersonic Missile Development**

A Research Paper Submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements of the Degree

Bachelor of Science, School of Engineering

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Spring 2024

On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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## Introduction

A 2021 paper titled *Slowing the Hypersonic Arms Race* claimed that the U.S. 's development of hypersonic missiles was devoid of rationality and was rather fueled by “hype” (Tracy). “Hype” has apparently led to the Department of Defense (DoD) spending “$8 billion since 2019 on programs to develop hypersonic missiles” and requesting another “$13 billion over the 2023-2027 period” in the 2023 Future Years Defense Program (United States, 2023). Such a notion is concerning on account of U.S. national security and fiscal responsibility. The allocation of the defense budget has a profound impact on military preparedness, which directly affects the U.S.’s ability to maintain a U.S.-led world order and protect its interests, as well as its international relationships. The theory of responsible innovation is an evolving one, but Stilgoe et. al. assert that anticipation, reflexivity, inclusion, and responsiveness are critical to responsible innovation (Stilgoe et. al., 2013). The following is the definition that Stilgoe et. al. provided for the aforementioned terms:

- Anticipation seeks to explore the “social, ethical and political stakes associated with technoscientific advances.”
- “Reflexivity … means holding a mirror up to one's own activities, commitments and assumptions, being aware of the limits of knowledge and being mindful that a particular framing of an issue may not be universally held.”
- Inclusion is incorporating “new voices in the governance of science and innovation as part of a search for legitimacy”
- Responsiveness “indicates a capacity to change shape or direction in response to stakeholder and public values and changing circumstances.”

The U.S.’s decision to pursue hypersonic missiles was irresponsible given its noncommittal adherence to these ideals. This paper comments on the adhesion of the DoD to these principles as it investigates the most prevalent factors that have influenced hypersonic missile development since 2000 in order to conclude whether the U.S. 's past and present investment in hypersonic missiles is responsible and justified.

## Background

The two mature types of missiles operated by the U.S. are the ballistic missile and the subsonic cruise missile. Warheads are either conventional or nuclear. A ballistic missile has a ballistic trajectory that can vary from short range to intercontinental. Intercontinental ballistic missiles (ICBMs) and submarine-launched ballistic missiles (SLBMs) traditionally have nuclear warheads. Their size of impact allows a greater margin of error in targeting, and during the Cold War, they were an integral part of the U.S.’s nuclear deterrence strategy against the Soviet Union. ICBMs, such as the Peacekeeper and Minuteman III, and SLBMs, such as the Trident, have

multiple independently targetable vehicles (MIRV) that are released upon reentry and bypass enemy terminal ballistic missile defenses. A “modified ICBM” refers to an ICBM that has been modified to carry conventional warheads, which requires greater targeting accuracy. A subsonic cruise missile has a shorter range and is slower and cheaper than a ballistic missile, and can be controlled throughout its flight path. It always carries conventional warheads. The Tomahawk cruise missile is an example of a subsonic cruise missile deployed by the U.S. (Britannica, 2024).

A hypersonic missile, in concept, has a speed and range comparable to the ballistic missile while being maneuverable throughout its flight path. Contrary to a ballistic missile, the U.S. designs it to solely carry conventional warheads. Instead of following a ballistic flight path that would take it outside the atmosphere mid-flight, it moves through the atmosphere. The atmosphere allows maneuverability, but in combination with hypersonic speed, it creates extremely high temperature and drag. The high temperature causes ionization of the atmosphere around the missile, which also blocks communications. These are the primary engineering challenges for this technology. Two types of hypersonic missiles are boost-glide and air-breathing. A boost-glide hypersonic missile is boosted into the atmosphere and uses momentum to glide to the target, while an air-breathing hypersonic missile intakes air for combustion and propulsion throughout its path (Tracy, 2021). The Air Force’s Common Aero Vehicle program (CAV) was one of the earliest boost-glide hypersonic missiles under research and development in the U.S. (Woolf, 2010).

Hypersonic missiles were originally proposed by the Department of Defense to fulfill the Prompt Global Strike (PGS) mission, which was spearheaded by the Bush Administration in an effort to get ahead in the War on Terrorism. In 2010, Amy Woolf of the Congressional Research Service (CRS), a shared staff to Congressional committees, wrote a report on why the DoD was pursuing a PGS mission and the mainstream critiques of it. Much of the subsequent discussion deals with the rationale behind the PGS mission as outlined by Woolf’s report, since hypersonic missiles were originally intended to fulfill it. Since then, the rationale for hypersonic missiles has evolved to encompass superpower competition and regional conflicts, which has introduced a new host of considerations and fueled their development into today.

**War on Terrorism**

The birth of the PGS mission demonstrated a great deal of responsiveness, since it was a strong pivot in military strategy when the Cold War yielded to the war on terrorism. During the Cold War, nuclear weapons formed the foundation of the U.S.’s military strategy. However, the collapse of the Soviet Union and the rise of terrorism demanded a different approach. Nuclear weapons were an ineffective deterrent against terrorist groups, who cared more about enacting the initial damage and sending a message than about the potential for retaliation. This fact increased the likelihood of actual conflict and prompted the DoD to look for a conventional

alternative. Thus, the PGS mission was to develop a missile with conventional warheads that could be launched from nearby the U.S. and reach anywhere in the world within a few hours (Woolf, 2010).

Woolf's 2010 summary report relayed that the unpredictability of terrorists' locations made strategic placement of U.S. bases difficult, prompting the DoD to desire a missile that could be launched reliably from nearby U.S. soil while still reaching targets worldwide; however, this was not explained beyond terrorists being more difficult to track than the Soviet Army. Reflexivity would demand further scrutiny before allowing it to influence technological innovation, but even a quick assessment sows doubt. In a timeline of terrorist activity between 1999 and 2001 constructed by the Office of the Director of National Intelligence, the countries Yemen, Israel, Turkey, Pakistan, India, Colombia, Sri Lanka, and the Philippines are listed most frequently (n.d.). Although this is quite a few, with the exception of Columbia, these countries were all contained in the Middle East and Southeast Asia as a result of the Israeli-Palestinian conflict, the Islamist separatist movement in the Philippines, and the rise of violent Marxist-Leninist groups in Turkey. A military base would only have to be within 1500 miles of the target for a cruise missile to be effective; for comparison, Egypt is about 800 miles wide (Britannica, 2014). Thus, it was excessive for the DoD to request a weapon independent of forward base placement entirely. Even if predicting terrorist groups' locations were an issue, a more direct solution would have been to invest in improved intelligence collection techniques or technologies, rather than building another weapon. In another vein, one could argue that the PGS mission was necessary because the cooperation of countries within striking distance of targets was unreliable. Guardian News reported that just weeks after 9/11, Saudi Arabia, considered a U.S. ally, rejected the U.S.'s request to use their Prince Sultan military base in its offensive against Osama bin Laden in fear of "stirring up long-suppressed internal conflicts" (Whitaker, 2001). Some civilian populations in these regions championed terrorist groups for standing up to the U.S., making it more difficult for the U.S. to elicit help from these countries' governments without potentially inciting further violence. Further study would be required to determine if another solution other than the PGS mission might be more effective. But the lack of reflection on the problem frame made for a doubtful justification for it.

Woolf listed "fleeting targets" as a reason for the PGS stipulation of speed, but the assumption that missile speed was the imperative capability should have been further assessed. The failed assassination attempts of Osama bin Laden in 1989 and Saddam Hussein in 2003 using subsonic cruise missiles were example scenarios used by the National Research Council to evaluate the effectiveness of existing technologies against proposed ones (2008). They demonstrated that the proposed technologies, including hypersonic missiles and modified ICBMs, were better in the characteristics of execution time, positioning, and reliance on bases, insinuating that an improvement in these characteristics might prevent similar failures. However, a 2009 article refuted the connection between these failed assassinations and the supposed

inadequacies of the U.S.'s existing missile technologies (Pollack). For the attempted assassination of bin Laden, Pollack referenced a book titled "The CIA and the Culture of Failure" by John Diamond (2008), the communications director for Senator Maria Cantwell, to assert that the failure to kill bin Laden originated with the arrest of one of bin Laden's co-conspirators that was supposed to be at the Khost camp meeting, alerting the al Qaeda leaders to danger and causing them to change plans. For Saddam Hussein, Pollack referred to a subsequent report by the U.S. Joint Forces, which deduced that Hussein was not present at Dora Farms in the first place, making the speed of the missile completely irrelevant, since the target itself was incorrect. Although there is inherent ambiguity in foreign conflicts, there needed to be a deeper analysis of exactly what went wrong so that a direct solution could be found. It seemed that the National Research Council took for granted the reliability of a single perspective on the issue, resulting in a one-dimensional evaluation of missile technologies. It is clear that in this case, greater inclusivity would yield greater reflexivity, and would call for a recognition of the diverse factors that had to align for a successful mission. As it was, the failure to kill bin Laden in 1998 left a lasting impression on the U.S. defense community in connection to hypersonic missiles development, with it referenced in a U.S. Army article on hypersonic missiles 20 years later (Aylward, 2018). The propagation of this jarring and overly simplified connection through the years would at least partially explain the U.S.'s dedication to the PGS mission and, subsequently, hypersonic missile development.

In the theme of greater inclusivity and reflexivity, the PGS mission should have been evaluated in comparison to other potential solutions instead of simply by itself. A 2007 paper written by Major Phinney, who was chief of contingency plans for the Seventh Air Force in Korea, came to an alternate conclusion for how anti-terrorism operations could be improved after assessing the successes and failures of Operation Infinite Reach (Phinney). Operation Infinite Reach had an objective "to strike at the network of radical groups affiliated with and funded by Osama bin Laden" using Tomahawk cruise missiles. Phinney claimed it did so successfully in striking the Khost terrorist training camp in Afghanistan and the El Shifa pharmaceutical plant in Sudan (although the actual involvement of the latter in terrorist activity was later contested). Interestingly, Phinney did not mention bin Laden's escape in his evaluation of Operation Infinite Reach, instead counting the bombing of the camp itself a success. He praised cruise missiles for avoiding the issue of accessing land bases in nearby countries while minimizing risk to American soldiers. In fact, he concluded that the primary drawback to cruise missiles was their expense, since each missile cost $600,000. To address this issue, Phinney suggested that the U.S. field an unmanned combat aerial vehicle with greater firepower, whose reusability would aid economic efficiency while maintaining versatility and minimizing risk to American soldiers. In light of his analysis, the suggestion of investing in a new missile with greater capabilities and greater expenses to perform a similar function to a cruise missile was counterintuitive. This approach of critically assessing past military strategies and outcomes in order to guide future technologies and operations vastly outpaces the trigger-happy approach that pervaded the Department of

Defense during Bush's reign as president. The presentation of the new military strategy as all-or-nothing, or rather PGS-or-nothing, undercut the DoD's ability to logically determine next steps.

**Nuclear ambiguity and deficient intelligence**

Although the PGS was seen as generally necessary for providing greater flexibility to the President and allowing the U.S. to react rapidly to any conflict anywhere in the world, Woolf identified the inherent risk of incorrect targeting due to insufficient intelligence. Ideally, the anticipation of this issue would yield a reaction proportional to the risk, but little was changed about the innovation approach. With such a rapid strike, intelligence could not be validated within a reasonable margin of error, leading to unnecessary casualties and damage. For U.S. airstrikes in Afghanistan from late-2005 to July 2008, "while just 11 civilian deaths have resulted from strikes planned in advance, the remainder of the 556 civilian deaths were attributed to unplanned attacks on targets of opportunity" (Pollack, 2009). While the lengthy 2008 report *U.S. Conventional Prompt Global Strike: Issues for 2008 and Beyond* by the National Research Council did not address this issue, rather focussing entirely on attack ambiguity as discussed below, the Defense Science Board's 2009 *Time Critical Strike Report* did, asserting that the Department of Defense's funding of time-critical strike delivery platforms needed to be balanced with "considerably increased" focus on intelligence, surveillance, and reconnaissance (ISR). Therefore, an already expensive initiative in the form of PGS relied on an expensive expansion of ISR capabilities. The fact that this risk was identified in 2009 by the National Research Council shows anticipation, but the Department of Defense showed lack of responsiveness by sticking to the original plan. Rather than shifting focus to ISR capabilities, the Department of Defense continued prioritizing the PGS mission, even though a failure in ISR would make a PGS capability moot.

Throughout its inception, funding for the PGS mission was stunted by Congress's concern that such a missile could be misinterpreted as a nuclear attack, but it was never fully shut down as it should have been. Again, this demonstrates anticipation, but lackluster responsiveness. Congress invested $5 million in 2007 to study this problem and come up with solutions, since it believed in the necessity of PGS, but none of the solutions were deemed sufficiently fool-proof (Woolf, 2010). Rather than cancel the program, Congress decided to authorize funding primarily for research related to the hypersonic glide vehicle solution, which it deemed avoided the issue best. A hypersonic glide vehicle could theoretically be maneuvered so that it wouldn't fly over particular third-party countries, therefore mitigating the risk that a country would mistakenly believe themselves to be the target. Thus from 2003 to 2007, Congress repeatedly blocked funding for the Navy's Conventional Trident Modification (CTM) program and actually exceeded the proposed funding for the Air Force's common aero vehicle (CAV) program. Despite this initial show of support for hypersonic programs, Congress got cold feet,

and in FY2007, limited the CAV program research to non-weapons-related research, while allocating funds to the CTM program, but only towards research and development, barring long-term procurement (Woolf, 2010). They essentially shot themselves in the foot – the main draw of the CTM program was that it could reach procurement relatively quickly, so to limit funding to research and not procurement was a waste of funding. In FY2008, Congress combined the funds into one account for what they called the Conventional Prompt Global Strike (CPGS) program, to which the Army would also have access, but then only provided less than half the requested funding for all the combined programs, totalling $100 million (Woolf, 2010). Essentially, in an effort to avoid the impending problem of nuclear ambiguity, Congress delayed the achievement of the CPGS mission, perhaps hoping that a better solution would present itself in the meantime and thinking that the research and development for the programs so far would be broadly applicable to national defense. What this really did was initiate several years of half-hearted funding for a complicated solution to a questionable mission.

**Competition with Russia and China**

One would've hoped that a change in presidency might produce a more systematic approach to defense investments, but Bush's PGS – renamed CPGS – idea was waved through by the Obama administration when it appeared to solve the problem of China's growing military power. Since then, the subject of hypersonic missiles has been synonymous with competition with China. Responsiveness means a capacity for change in reaction to changing circumstances, which the DoD didn't demonstrate when it plowed on with the CPGS mission when priorities changed. In 2009, when the Defense Science Board was tasked with evaluating time-critical conventional strike options for realistic scenarios, one such scenario was that "A near-peer competitor had used its emerging counter-space capability to destroy a U.S. satellite." In 2013, an article published by the Carnegie Institute for International Peace mentioned "China's evolving anti-satellite capability" as providing a rationale for CPGS (Acton). More recently, hypersonic missiles have been seen as addressing China's expanding Anti-Access/Area Denial (A2/AD) capabilities. The Congressional Budget Office's (CBO) 2023 *U.S. Hypersonic Weapons and Alternatives* asserted that China's A2/AD had "the potential to limit U.S. naval and air access to much of the South China Sea, particularly because China could extend the reach of those weapons by basing them on disputed islands in the South China Sea." In fact, the report's chapter on "scenarios that define potential requirements for hypersonic missiles" was dedicated almost entirely to potential conflicts with China or Russia, with the exception of one sentence that mentions the targeting of a leader of a terrorist organization. The 2021 report *Slowing the Hypersonic Arms Race* looked speculatively at the fact that the PGS mission was originally proposed in the context of the war on terrorism but evolved to be applied to near-peer competitors, and rightly so (Tracy). The Obama administration, rather than going back to the drawing board, took the easy way out by piggybacking on the solution derived by the Bush administration. It was seen as a credit to the CPGS mission that it would address the issue of

both terrorism and major power rivalry, and this shift in focus in 2009 fueled rather than hindered support for the CPGS mission (Acton, 2013).

An unfortunate but predictable consequence of focussing CPGS on near-peer adversaries was triggering another arms race. The New START treaty between the U.S. and Russia only placed limits on equipment for their nuclear stockpiles, leaving the area of hypersonic missiles completely open (U.S. Department of State, 2023). While CPGS has only been referenced to target the nuclear arms of rogue states, Russia interpreted it as a threat to its own nuclear deterrent (Acton 2013). As of 2019, Russia was developing three hypersonic missiles that could carry nuclear warheads (Bernstein and Menke, 2019), and it is suspected that Russia deployed their Zircon hypersonic missile in its war against Ukraine (Lendon, 2024). As of 2021, China had one operable hypersonic missile with several others in testing (Bernstein and Hancock, 2021). While it is yet uncertain what lasting consequences hypersonic missiles will have on global arms stability, the mutual conquest of hypersonic missiles by the U.S., China, and Russia is reflective of mounting tensions between the three powers, and it was the U.S. that started it. In his book, *A World in Disarray*, Haass aptly identifies the line that the U.S. must tread where it maintains military readiness without acquiring military capabilities that threaten global stability (2018). When the reasons for hypersonic missile development are so poorly supported, and anticipation dictates that acquiring them could instigate tensions between dangerous states, hypersonic missile development should've been avoided altogether.

**Conclusion**

U.S.'s decision to pursue hypersonic missiles was a result of irresponsible innovation. Although the call for advancements in conventional forces was responsive in light of the Soviet Union's collapse, the PGS mission was misguided. The scenarios that were used to justify the PGS mission were not analyzed and presented with the complexity required to truly understand their implications. Even hypothetical scenarios that might require PGS would rarely occur, since the target would have to occur far enough from U.S. land and sea-based forces and require such an early response such that the U.S. would not have time to move forces there. The specification of speed in the PGS mission introduced a problem with target confidence, which meant that an equal or greater measure of innovation was required in the area of ISR in order for PGS to be viable. However, the anticipation of this issue did not lead to a correction in innovation strategy. Congress's anticipation of nuclear ambiguity led them to favor the hypersonic missile solution over others, but they did not do so with the conviction necessary for methodical problem-solving. When the U.S.'s priorities shifted from terrorism to superpower competition, its military strategy did not also shift. Hypersonic missile development was neither justified in the context of the war on terrorism, nor in regional conflicts with China or Russia.

The primary element of responsible innovation that the U.S. appears to be deficient in is reflexivity. Before investing in a new technology, the U.S. must reflect on why the technology is necessary and allow for the case that its initial assumptions were incorrect. Although much of military strategy is the anticipation of future conflicts, the U.S. should utilize lessons learned from past conflicts to guide technological development. The issue of responsible innovation in U.S. defense can be further studied by analyzing the mechanisms by which the DoD, Congress, Congressional staff, and nonprofit organizations communicate and collaborate. Studying why certain technologies are pursued is helpful in identifying specific gaps in reasoning, but the underlying issue likely lies with the process by which new technologies are proposed and pursued. It may be due for an overhaul.

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