

# Understanding Hypersonic Weapons: Managing the Allure and the Risks

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An Arms Control Association Report

September 2021



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## Acknowledgments

The authors would like to thank the Arms Control Association's Executive Director Daryl G. Kimball for his assistance in reviewing this report and Julia Masterson, research associate, for her copy edit. Special thanks to Allen Harris for the report's layout and design.

James Acton, Michael Klare, and Sam Wilson provided thoughtful feedback on this report. The authors would also like to acknowledge the German Federal Foreign Office and the European Leadership Network for their support.

The authors are responsible for the content of the report, and the statements made and views expressed do not necessarily represent the views of the Arms Control Association's Board of Directors.

## Cover Photo

Airmen from the 912th Aircraft Maintenance Squadron secure the AGM-183A Air-launched Rapid Response Weapon (ARRW) as it is loaded under the wing of a B-52H bomber during a test at Edwards Air Force Base, Calif., on Aug. 6, 2020. (Photo by U.S. Air Force)

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# Executive Summary

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Depending on who you talk to in Washington, DC, defense and national policy circles, hypersonic weapons are “super-duper” missiles poised to revolutionize warfare because they are impossible to defend against. Others say they are but the latest in a long line of overhyped weapons systems and are relatively easy to defend against because they actually fly more slowly as they near their target than ballistic missiles with comparable ranges. Some claim that hypersonic weapons will strengthen conventional deterrence by leveling the playing field with adversaries who are also developing—and have already deployed—hypersonic weapons. Still others argue they will create instability between nuclear-armed nations by increasing fears of a disarming attack and by fueling a dangerous arms race.

This debate has gained increased attention in recent years as the United States has poured billions of dollars—and plans to pour billions more—into accelerating the development of hypersonic weapons and as China and Russia make headway in developing and deploying their own such weapons. The U.S. Department of Defense is funding no less than eight prototype hypersonic weapons programs with the aim of fielding an initial capability of at least some of those by 2022 amid a renewed emphasis on competition with Beijing and Moscow. Russia fielded the Avangard, a hypersonic glide vehicle, in 2019 and is developing an air-launched hypersonic missile (the Kinzhal) and a sea-launched hypersonic cruise missile (the Tsirkon). China displayed a ballistic missile designed specifically to carry a hypersonic glide vehicle (the DF-17) during its 2019 military parade. While Washington is only pursuing conventional hypersonic weapons at this time, Beijing and Moscow appear to be seeking not only conventional but also nuclear or dual-capable hypersonic capabilities.

Thus far, the Defense Department has offered varying and at times conflicting rationales for pursuing hypersonic missiles. It has not offered

a clear concept of operations for the deployment of the weapons or a detailed explanation for why alternative military capabilities are not adequate to meet mission requirements. Other important details about the department’s plans for the weapons are yet to be determined, including the projected costs of the missile systems under development and production quantities. Meanwhile, the Pentagon appears to be paying less attention to the ways in which hypersonic weapons could lead to new escalation dangers in a conflict, including to the nuclear level, and contribute to a burgeoning arms race with all sides rushing the deployment of the new weapons lest they be perceived as falling behind the others in mastery of the new technologies involved.

The Pentagon’s current pedal-through-the-floor development approach to hypersonic weapons enjoys strong bipartisan support in Congress. Most lawmakers seem convinced that the United States must have hypersonic weapons simply because China and Russia are pursuing them. For its part, the Biden administration appears likely to continue many, if not all, of the prototyping efforts begun under the Trump administration as part of its prioritization of



**The Defense Department has offered varying and at times conflicting rationales for the U.S. pursuit of hypersonic weapons.**  
(Photo by Staff/AFP via Getty Images)

long-range precision fires to strengthen conventional deterrence against China and Russia.

But the U.S. rush to field hypersonic weapons merits a more critical examination by the Biden administration and Congress given the many unanswered questions about their rationale, technical viability, cost-effectiveness, and escalatory risks. This report outlines the scope of these unanswered questions, details the underappreciated risks to stability posed by the weapons, assesses the viability of arms control as a tool to reduce the risks, and suggests recommended action items for Congress to better its understanding about the Pentagon's plans for the weapons, eliminate potential redundancies in weapons capabilities, and mitigate stability risks.

Section I of the report describes the characteristics of hypersonic glide vehicles (HGVs) and hypersonic cruise missiles (HCMs), some of the technical challenges the weapons have yet to overcome, and how both proponents and skeptics view the benefits and downsides of the weapons relative to existing missile capabilities.

Section II provides an overview of the current hypersonic weapons programs in China, Russia,

and the United States, along with a review of each country's stated motivations—to the extent they can be ascertained—for pursuing the weapons.

Section III examines the possible risks hypersonic weapons pose to strategic stability. Such risks include those emanating from target and warhead ambiguity, a reduction in response time, the potential ability to target mobile missiles, arms racing, and exacerbating threats posed by other emerging technologies.

Section IV outlines how arms control might be applied to hypersonic weapons to mitigate the risks they pose and to curb unconstrained competition. Experts have begun to explore various options ranging from confidence-building measures to bans or limits on certain types of weapons. There are also unilateral steps that the United States could take to minimize escalatory risks.

Finally, Section V proposes six recommended action items for Congress to scrutinize the Defense Department's plans to develop and field new hypersonic weapons, consider adjustments to the programs, and make better-informed decisions regarding hypersonic weapons program oversight and funding.

## Section I:

# What are Hypersonic Weapons?

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A hypersonic missile is a missile that travels at least five times the speed of sound (Mach 5). Most traditional ballistic missiles fly at hypersonic speeds, whereas most traditional cruise missiles fly at subsonic (less than Mach 1) and supersonic (Mach 1 to 5) speeds. For example, the Minuteman III, the United States' nuclear-armed intercontinental ballistic missile (ICBM), can hit Mach 23 at burnout and would reach Russia from silos housed in the western United States within about 30 minutes after launching.<sup>1</sup> In practice, the term “hypersonic weapons” has generally come to mean missiles that fly at lower altitudes than ICBMs and greater altitudes than traditional cruise missiles and that are largely intended for regional rather than intercontinental use.

The hypersonic weapons that are the main focus of this report are the two new types under development: hypersonic glide vehicles (HGVs) and hypersonic cruise missiles (HCMs).

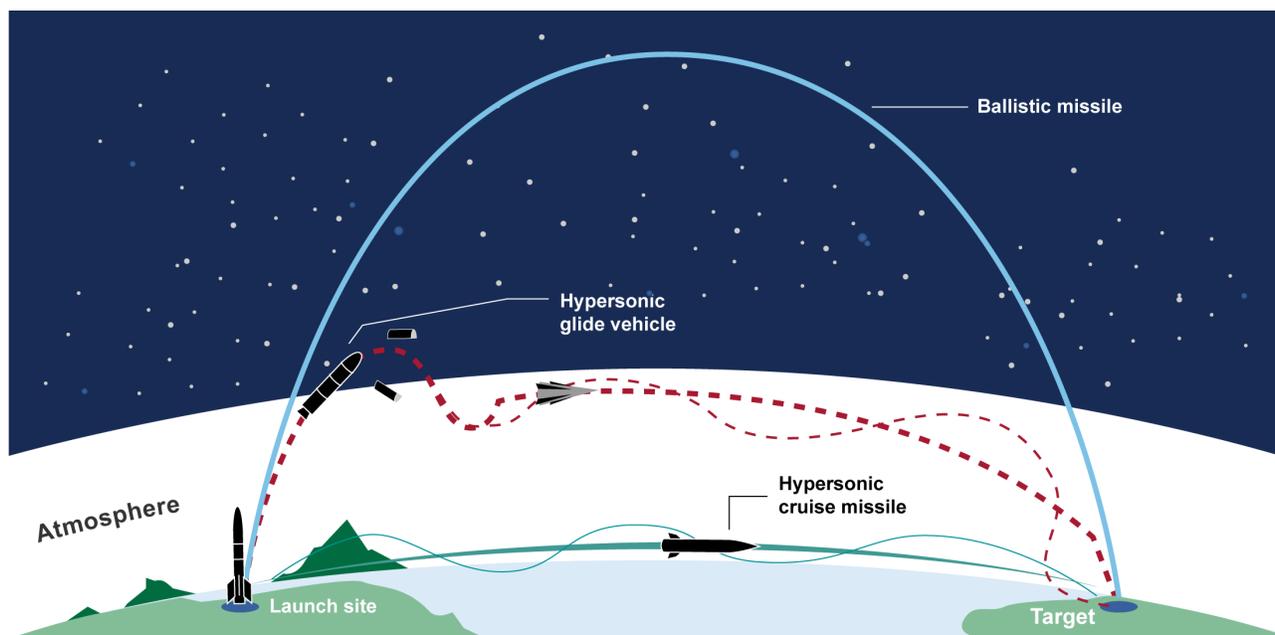
HGVs are launched by a rocket before gliding to a target, fly at lower altitudes than ballistic missiles, and feature significant maneuverability. HCMs are powered by high-speed engines, called scramjets, during flight and are intended to fly at both greater speed and greater altitudes than traditional cruise missiles.<sup>2</sup> Both types can carry conventional or nuclear payloads. Conventional variants may be able to rely on the kinetic energy, or the energy derived from their high speed, to destroy their intended targets.

This fusion of speed, maneuverability, and unique altitudes, plus the suggestion by some U.S. defense officials that the weapons are more accurate,<sup>3</sup> helps to explain the attention that their development has garnered in recent years. In particular, these

characteristics are said to offer the potential to enhance the probability of destroying high-value, heavily defended, and time-sensitive targets, such as road-mobile missiles and surface-to-air missiles. “Hypersonic weapons are an evolution in technology that does present...very different, qualitatively different, considerations for strategy, and therefore it is a game-changer,” argues Rebecca Heinrichs, a senior fellow at the Hudson Institute.<sup>4</sup>

Yet, there exists significant debate among defense officials and experts about whether hypersonic weapons, in particular HGVs, will work as intended, prove cost-effective, and offer militarily relevant advantages in their use as compared to alternatives such as already existing ballistic and cruise missiles.

Ballistic missiles follow a largely predictable, arched trajectory, flying high above the atmosphere before plummeting back towards Earth. This permits those on the receiving end to more easily track the ballistic



**Ballistic missiles follow a largely predictable, arched trajectory, flying high above the atmosphere before plummeting back towards Earth. Hypersonic glide vehicles and cruise missiles fly at lower altitudes within the atmosphere and follow different flight paths.** (Illustration by United States Government Accountability Office)

missile in its midcourse stage of flight through radar and to derive reasonable predictions on where the missile's warhead(s) will land.

HGVs, however, follow a different path and so are said to be less detectable by adversary radars. "[R]adar will detect these vehicles relatively late in their mid-course flight (that is, their glide phase) because they fly at low altitudes compared to ballistic missiles," writes Dean Wilkening, a former senior staff scientist at the Johns Hopkins Applied Physics Laboratory.<sup>5</sup> With HGVs reaching between 40km and 100km in altitude and HCMs flying between 20km and 30km,<sup>6</sup> these weapons can use aerodynamic forces to maneuver and adjust or course-correct their trajectory throughout the majority of their flight.

To be sure, ballistic missiles feature a degree of maneuverability. But as Cameron Tracy, the Kendall fellow for the global security program at the Union of Concerned Scientists, notes "the maneuverability of hypersonic missiles is far superior to that of ballistic missiles."<sup>7</sup>

"Since hypersonic weapons fly through the atmosphere, they can take advantage of aerodynamic forces to course-correct over most of their flight paths," he writes. "Ballistic missiles, in contrast, can execute corrective maneuvers only for brief periods during their initial ascent out of the atmosphere and

final descent to Earth, assuming they are fitted with a special maneuvering reentry vehicle (MaRV)."

But the flight of hypersonic weapons at a low altitude does come with drawbacks, according to Tracy. "Drag from the surrounding air [in the atmosphere] robs these missiles of much of their speed by the time they reach a distant target, giving them an average speed lower than that of ballistic missiles," he writes.<sup>8</sup> Plus, during their atmospheric flight, HGVs experience more extreme heating, which can erode missile material and alter their aerodynamics. The effects from such immense heat can also block communication with satellites and other external sources of guidance, thereby weakening control.<sup>9</sup>

Public details on U.S. progress toward overcoming these challenges have been scarce. A September 2020 press release from the U.S. Defense Advanced Research Projects Agency (DARPA) stated vaguely that future testing will focus, in part, on "thermal management techniques."<sup>10</sup> Meanwhile, the Navy, in its fiscal year 2021 budget justification books, listed "unique challenges like extreme temperatures and air flow" as areas of continued hypersonic research.<sup>11</sup>

The heating problem is not as concerning with respect to HCMs, according to James Acton, co-director of the nuclear policy program at the Carnegie Endowment for International Peace. Since cruise



**A missile carrying a common hypersonic glide body launches from the Pacific Missile Range Facility in Hawaii on March 19, 2020.** (Photo by U.S. Department of Defense)

missiles fly slower than rocket-launched systems, he writes, “their aerodynamic regime is better understood.”<sup>12</sup> Challenges facing HCMs include controlling the hypersonic flow of air through the scramjet engine to ensure stable combustion and managing the temperature of that air passing through the engine.

In addition to overcoming the challenges to flight, the accuracy demands for HGVs and HCMs, specifically conventional variants, could be greater relative to existing missiles. If conventional HGVs and HCMs must rely on kinetic energy to destroy their respective targets, they would have to hit their targets with extreme precision in order to ensure target destruction.<sup>13</sup>

Then-Secretary of the Army Ryan McCarthy said in October 2020 that “hypersonic missiles are hitting their targets with a variance of only a mere six inches,” referring to the test of a common hypersonic glide body under development by the Army and Navy in March of that year.<sup>14</sup> But Tracy casts doubt on the assertion that hypersonic weapons can strike with pinpoint accuracy, and he instead argues that guidance precision and atmospheric effects could diminish accuracy.<sup>15</sup>

The conventional wisdom holds that given their unique flight altitude profile and high speed, HGVs and HCMs pose challenges to many existing types of

air and missile defenses. This would allow them to provide a higher probability of carrying out a successful strike. In the words of Gen. Mark Milley, chairman of the Joint Chiefs of Staff: “There is no defense against hypersonic...You’re not going to defend against it... Those things are going so fast, you’re not going to get it.”<sup>16</sup> Nonetheless, the United States has begun investing in defensive capabilities to defend against hypersonic payloads. U.S. defense officials say that doing so “will require the development of wholly new intercept systems, supporting technologies, and a new sensor architecture.”<sup>17</sup> At this time, only the United States is known to be developing a defense system to defend against HGVs.<sup>18</sup> Initial U.S. defensive efforts against hypersonic weapons are focused on intercepting regional hypersonic threats during their terminal phase.

HGVs pose a particular problem for broad-area midcourse missile defenses, which form the backbone of the U.S. missile defense architecture. Such defenses, meant to protect a large region, are designed to intercept missiles in their midcourse phase outside the Earth’s atmosphere. Since an HGV maneuvers during its midcourse phase and travels inside the Earth’s atmosphere at lower altitudes, the defenses would be hard-pressed to successfully intercept the vehicle. Furthermore, existing midcourse defenses rely primarily upon land- and sea-based radars to detect

and track an incoming missile, and those radars would likely be less effective against HGVs.<sup>19</sup>

Acton, however, posits that point defenses, which protect particular targets, may prove more efficient against HGVs. This is due to the fact that, once within the atmosphere, the HGV will travel slower by the time it reaches its target due to drag, thereby bettering the chances of success for point defenses designed for a terminal stage intercept.<sup>20</sup>

Another area of debate is whether hypersonic weapons, and HGVs in particular, can be purchased at a cost-effective price. Paul Schaare, the vice president and director of studies at the Center for a New American Security, and Ainikki Riikonen, a research assistant at the Center for a New American Security, warn that “Even once the technology is developed, hypersonic missiles are unlikely to be affordable enough to be anything other than an exquisite silver bullet for the highest priority targets.”<sup>21</sup>

The Defense Department appears to be developing HCMs in part to guard against the concern that HGVs might be unaffordable. “The mission for the cruise missile has to do with—or the value proposition, let me put it in that term, the fact that the cruise missile is smaller, so it—it’s more affordable, and it fits on a wider range of platforms,” Michael White, assistant director for hypersonic weapons in the office of the undersecretary of defense for research and engineering, told reporters in March 2020.<sup>22</sup>

Concerns about the potential limitations of HGVs have also prompted questions about whether their use provides distinct advantages over the use of other existing types of missiles, especially ballistic missiles. “Most of the missions proposed for hypersonic gliders, such as a quick attack on a fleeting target, are already met, or could be met, just as well by ballistic missiles,” writes Ivan Oelrich, former vice president of the Federation of American Scientists.<sup>23</sup> “Perhaps



**Michael White leads efforts on hypersonic weapons development in the office of the undersecretary of defense for research and engineering.**

(Photo by U.S. Department of Defense)

not ballistic missiles deployed today,” he adds, “but missiles that could be developed using lower-risk technology, perhaps by modification of existing weapons.”

Other alternatives such as stealth and forward deployments could also provide military capabilities that could be more cost-effective than hypersonic weapons at achieving a given military requirement.

## Section II:

# Who is Developing Hypersonic Weapons and Why?

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**C**urrently, China, Russia, and the United States are the top pursuers of HGVs and HCMs. While the United States is at present focused solely on a conventional capability for the weapons, China and Russia are pursuing weapons that can also carry nuclear warheads.

Meanwhile, Australia, India, France, Japan, and Germany are also developing hypersonic weapons technology, though these efforts are beyond the scope of this paper.<sup>24</sup>

### The United States

The Trump administration requested a total of \$5.8 billion for all hypersonic-related research and development for fiscal years 2020 and 2021. In May, the Biden administration released its fiscal year 2022 budget request, which asked for \$3.8 billion for all hypersonic-related work at the Defense Department. The Biden administration appears intent on speeding ahead with plans that began under the Trump administration for the development and deployment of offensive hypersonic weapons programs as part of a continued emphasis on strengthening conventional deterrence against China and Russia.

Defense Secretary Lloyd Austin said June 10 that “This budget supports our efforts to...accelerate investments in cutting-edge capabilities that will define the future fight, such as hypersonics and long-range fires.”<sup>25</sup>

The \$3.8 billion covers efforts within the Army, Air Force, and Navy as they each pursue hypersonic weapon prototypes, some with ranges exceeding 3,000km. It also includes the Defense Advanced Research Projects Agency’s (DARPA) research and development work related to hypersonic weapons and

the Missile Defense Agency’s pursuit of a hypersonic weapons defense program.

The main military rationale given for the U.S. pursuit of HGVs and HCMs by Pentagon officials appears to be to ensure defeat of advancing adversary, particularly Chinese, air and missile defenses and to enable destruction of fleeting targets, including adversary hypersonic weapons.

“These capabilities help ensure that our warfighters will maintain the battlefield dominance necessary to deter, and if necessary, defeat any future adversary,” said White in March 2020.<sup>26</sup> Under this view, existing U.S. conventional missile capabilities, which fly at subsonic speeds, lack the speed and maneuverability necessary to contend with advancing adversary threats. Existing subsonic cruise missiles, such as the Tomahawk sea-launched cruise missile and the Joint Air to Surface Standoff Missile (JASSM), “will take on the order of 10 times longer to fly long-range strike missions when compared to the adversary’s high-speed systems,” White added in May. “It presents a battlefield asymmetry and timescale that we simply cannot allow to stand.”<sup>27</sup>

According to Gen. John Hyten, currently vice chairman of the Joint Chiefs of Staff, hypersonic weapons will allow for “responsive, long-range, strike options against distant, defended, and/or time-critical threats when other forces are unavailable, denied access, or not preferred.”<sup>28</sup>

## U.S. Hypersonic Weapons Programs

Lead	conventional, nuclear, dual-capable	Description	Speed	Range (in kilometers)	Schedule
<b>AGM-183 Air-Launched Rapid Response Weapon (ARRW)</b>					
Air Force	conventional	an air-launched hypersonic glide vehicle, using Tactical Boost Glide technology and with a tungsten fragmentation warhead (which is limited to soft targets)	Mach 6.5–8	1,600	initial operating capability in FY 2022
FY 2021 (\$ thousands—enacted)		386,157	FY 2022 (\$ thousands—requested)		399,112
<b>Hypersonic Attack Cruise Missile (HACM)</b>					
Air Force	conventional	a hypersonic cruise missile, using air-breathing technology	Mach 5+*	unknown*	new start program in FY 2022; complete critical design review in FY2023
FY 2021 (\$ thousands—enacted)		N/A	FY 2022 (\$ thousands—requested)		200,116
<b>Long-Range Hypersonic Weapon (LRHW, also called Dark Eagle)</b>					
Army	conventional	the common hypersonic glide body paired with the Navy's booster system on mobile ground platforms; at least the first battery will feature a tungsten fragmentation warhead	Mach 5+*	2,775	initial operating capability in FY 2023
FY 2021 (\$ thousands—enacted)		832,166	FY 2022 (\$ thousands—requested)		412,401
<b>Conventional Prompt Strike (CPS)</b>					
Navy	conventional	the common hypersonic glide body paired with a submarine-launched booster system on Zumwalt-class destroyers and Virginia-class submarines; this system may feature the tungsten fragmentation warhead or an alternative warhead	Mach 5+*	unknown*	initial operating capability on Zumwalt-class destroyers in FY 2025 and on Virginia-class submarines in FY 2028
FY 2021 (\$ thousands—enacted)		767,637	FY 2022 (\$ thousands—requested)		1,374,000
<b>Offensive Anti-Surface Warfare Increment II (OASuW-2)</b>					
Navy	conventional	an air-launched, long-range hypersonic weapon system	Mach 5+*	unknown*	new start program in FY 2022; planned for deployment in the 2030s
FY 2021 (\$ thousands—enacted)		N/A	FY 2022 (\$ thousands—requested)		56,964
<b>Tactical Boost Glide (TBG)</b>					
DARPA	conventional	a hypersonic boost-glide vehicle; capabilities planned for Air Force and Navy	Mach 7+	tactical	testing through FY 2022
FY 2021 (\$ thousands—enacted)		81,858	FY 2022 (\$ thousands—requested)		50,043
<b>Operation Fires (OpFires)</b>					
DARPA	conventional	a ground-launched system with TBG technology; capabilities planned for the Army	Mach 5+*	intermediate	complete critical design review in FY 2022
FY 2021 (\$ thousands—enacted)		47,575	FY 2022 (\$ thousands—requested)		45,000
<b>Hypersonic Air-Breathing Weapon Concept (HAWC)</b>					
DARPA	conventional	an air-launched hypersonic cruise missile that could be compatible with a variety of launch platforms; capabilities planned for the Air Force	Mach 5+*	unknown*	complete final program review in FY 2022
FY 2021 (\$ thousands—enacted)		30,880	FY 2022 (\$ thousands—requested)		10,000

\*no estimate or information publicly available

## U.S. Hypersonic Missile Defense

Program	Lead	Description	Schedule	FY2021 (\$ thousands– enacted)	FY2022 (\$ thousands– requested)
Hypersonic Defense	Missile Defense Agency	a layered defensive architecture to address regional hypersonic threats that uses the Aegis Weapon System and includes the development of a Glide Phase Interceptor (GPI)	begin fielding GPIs in the mid- to late-2020s	272,632	247,931
Hypersonic and Ballistic Tracking Space Sensor (HBTSS)	Missile Defense Agency	a multilayered network of satellites in low Earth orbit, working alongside the Space Development Agency's National Defense Space Architecture	prototype satellites to be launched in FY 2023	130,000	256,222

But the motivations given by Pentagon officials have varied.

Other officials have focused less on the military benefits and more on the need to win the competition with China and Russia on the development of the technology. Michael Griffin, a former undersecretary of defense for research and engineering, has emphasized that the United States needs to develop the weapons in order “to allow us to match what our adversaries are doing.”<sup>29</sup> Griffin has also said that the United States will “raise them one, in both offensive and defensive capabilities.”<sup>30</sup>

Sam Wilson of the Aerospace Corporation has characterized the goals described by Griffin as the “Get Ahead” viewpoint. “The organizing principle of Get Ahead is that by becoming the leader in hypersonic missile development, the United States can achieve a strategic advantage over Russia and China,” Wilson writes. “Such an advantage, according to the approach, would offer warfighting and deterrence benefits.”<sup>31</sup>

The different motivations put forward by defense officials raise questions about whether specific military requirements are driving U.S. development decisions, or if the main driver is to weaponize the technology now and figure out specific roles and missions later.

Maj. Gen. Mark Weatherington, commander of the 8th Air Force and the Joint-Global Strike Operations Center, said last year that the Air Force is still crafting its concept of operations for hypersonic weapons. He posited a handful of questions that the Air Force has yet to answer: “How are we going to employ hypersonic weapons? What do they bring to the battlefield? What are our considerations for planning and executing and integrating them in a fight? How do we understand the target, where it’s at, where it may be going, and make sure we can close that kill chain on a particular target?”<sup>32</sup>

David Zikusoka, a former research fellow at the Center for Strategic and Budgetary Assessments, has called the U.S. development approach the “prototype-first approach.”<sup>33</sup> “On one hand, this prototype-first approach could support the rapid operational deployment of hypersonic capabilities,” he writes. “On the other, the United States is taking risk by developing these systems without comprehensive requirements (a defined set of attributes, functions, and quantities) that could illuminate how these weapons fit comparatively and complementarily into the strike portfolio.”

U.S. military officials do not claim that HGVs and HCMs should necessarily replace existing missile and bomb inventories. Rather they argue that the hypersonic missiles would allow existing weapons to be more effective. “The actual purpose for all of our investment is to supplement our existing theater strike capability using traditional cruise missiles, as well as penetrating aircraft,” White said in February 2021.<sup>34</sup>

Proponents also view hypersonic weapons as an option for strikes against challenging time-sensitive targets to destroy, such as mobile missiles. Given their ability to relocate, this type of target has long been difficult to identify, track, and successfully destroy before the missile launches. Subsonic missiles, Zikusoka writes, “would struggle to strike mobile missiles in time to make a difference.” But while faster flying HGVs and HCMs could in theory have a better chance of destroying relocatable targets than subsonic alternatives, it is far from clear that they would be able to do so given persisting challenges such as determining the precise location of and delivering a weapon to such a target in sufficient time.

The Defense Department’s desired production goals for HGVs and/or HCMs is unclear. A smaller number, say in the dozens to low hundreds, would suggest a desire for a niche capability, while higher numbers would point to a desire for a more robust war-fighting capability.

“If we talk about ballistic missile defense or hypersonic offense and we talk about proliferating architectures, we need many dozens, many hundreds, maybe thousands of assets,” said Griffin in 2019. “This takes us back to the Cold War where at one point we had 30,000 nuclear warheads and missiles to launch them.”<sup>35</sup> A few months later, Griffin declined “to quote a number,” but said that “we are making a major investment in production of hypersonic weaponry at scale” and “we’re going to be making a major investment of many billions of dollars.”<sup>36</sup>

There is debate within the expert community about how many of these weapons the United States should buy and deploy. Wilkening has called for fielding “enough forces to deter Chinese hypersonic attacks against our carriers and airfields and other critical targets in the Western Pacific.” In this case, he says, “I come up with numbers in the many hundreds if not several thousand such targets, and so to me, you need inventories on that size.”<sup>37</sup> Jill Hruby, currently administrator of the National Nuclear Security Administration, however, suggests that hypersonic weapons could be used for “surgical strike capabilities,” which would require “tens” of them.<sup>38</sup>

In addition to uncertainty about concepts of operations for and desired numbers of hypersonic weapons, the Defense Department has yet to establish any official programs of record for the weapons. According to the Congressional Research Service, this suggests that the Pentagon “may not have approved either requirements for the systems or long-term funding plans.”<sup>39</sup> Nevertheless, the Pentagon has adopted an “aggressive” schedule for flight tests, with three HGV flight tests planned for 2021 and as many as 40 hypersonic weapons tests over the next five years, according to a March 2021 report by the Government Accountability Office (GAO). The GAO expressed skepticism about the schedule due to “logistical constraints” and the use of “immature technologies.”<sup>40</sup>

Despite significant U.S. investment in the accelerated development of conventional hypersonic weapons for each of the military services, an internal debate within the department about the rationale for the Army’s Long-Range Hypersonic Weapon (LRHW) has spilled out into the open. “I genuinely struggle with the credibility” of the Army’s plan to develop the LRHW, Gen. Timothy M. Ray, chief of Air Force Global Strike Command, said in April.<sup>41</sup> “I just think it’s a stupid idea to go and invest that kind of money that recreates something that the service [Air Force] has mastered and that we’re doing already right now. Why in the world would you try that?”

The Army is developing a suite of ground-launched missiles with a range exceeding the 500-kilometer limit once prohibited by the 1987 Intermediate-Range Nuclear Forces (INF) Treaty, including the Precision

Strike Missile, a mid-range missile capability, and the LRHW—though whether the LRHW would have violated the letter of the treaty remains a subject of debate.<sup>42</sup> Several Pentagon officials have made a strong push for the development of longer-range ground-launched missiles to complement the long-range air and sea capabilities already provided by the Air Force and Navy. “A wider base of long-range precision fires...is critically important to stabilize what is becoming a more unstable environment in the western Pacific,” Adm. Philip Davidson, then-head of U.S. Indo-Pacific Command, told the Senate Armed Services Committee in March.<sup>43</sup>

Ray’s criticism of the Army’s plans suggests the Pentagon is not unified on the best way forward for the long-range strike mission and highlights the funding challenges ahead, particularly amid projected flat defense budgets in the coming years. “Why would we entertain a brutally expensive idea, when we don’t, as a department, have the money?” Ray asked in reference to the projected cost of the Army’s LRHW.

Ray also raised questions about the ability of the Army to find basing options for the weapon. The Army, he said, is trying to “skate right past that brutal reality to check that some of those countries are never going to let you put...stuff like that in their theater... Just go ask your allies.”

Some Army officials have also acknowledged the diplomatic challenge associated with basing. “It may be that none of our allies and partners in the Pacific want long-range fires” on their soil, Col. Jason Charland, a senior Army strategist at the Pentagon, told *Breaking Defense* in March.<sup>44</sup> In the wake of the U.S. withdrawal from the INF Treaty in 2019, U.S. allies and partners, including Australia, Japan, and South Korea, all rejected the prospect of hosting missiles formerly banned under the accord.<sup>45</sup>

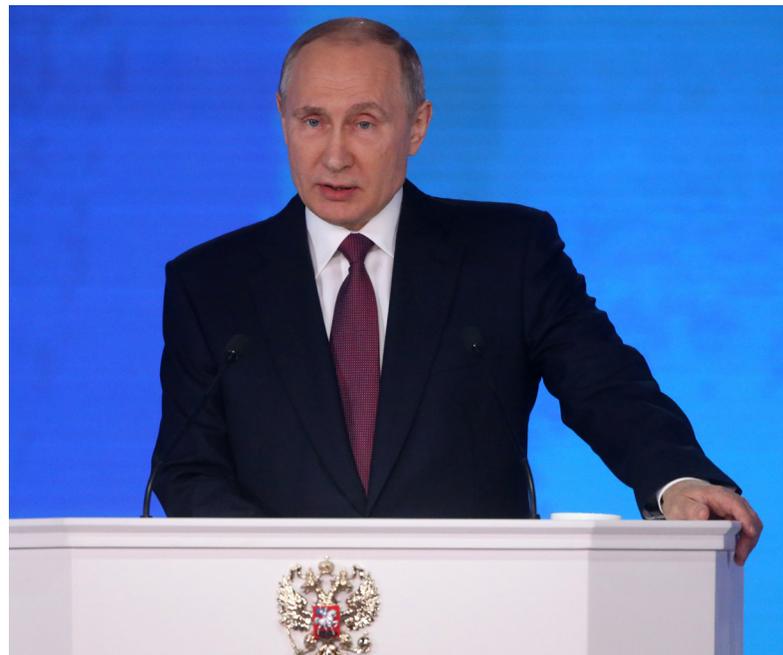


**Gen. Timothy M. Ray, commander of Air Force Global Strike Command, has raised questions about the rationale for the Army’s Long-Range Hypersonic Weapon (LRHW).**  
(Photo by U.S. Air Force)

## Russia

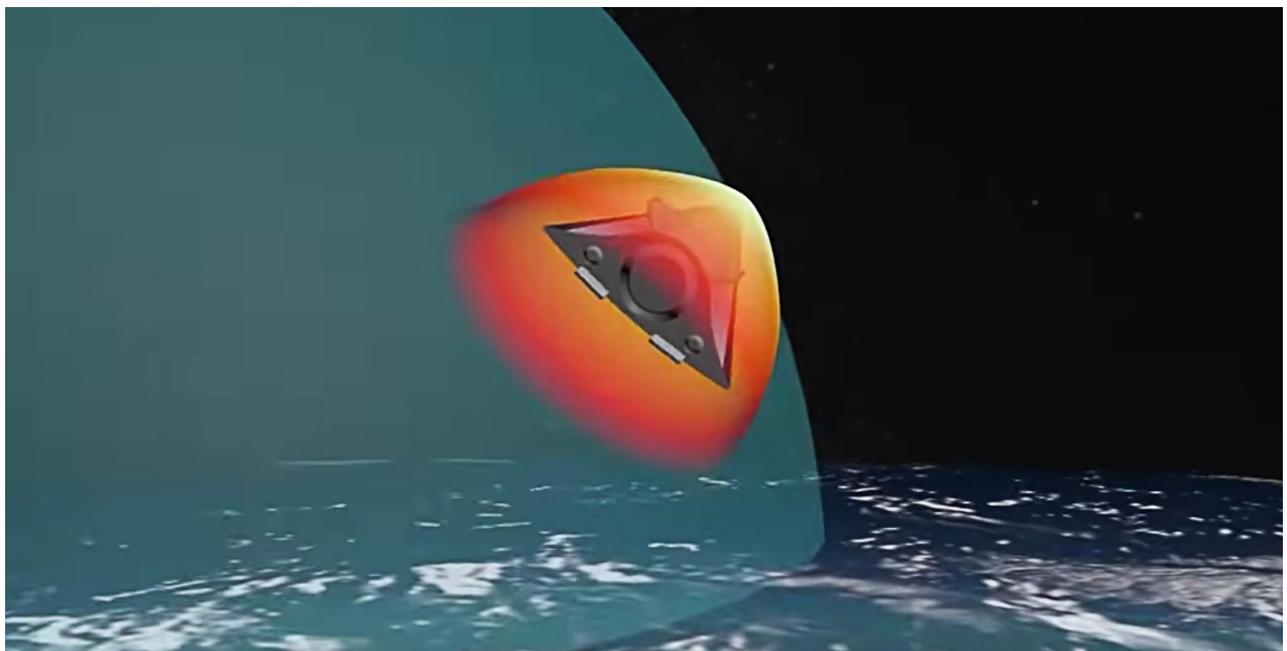
Russia has made no secret of its stated impetus for its development and deployment of hypersonic weapons, saying they are intended to ensure Moscow has weapons capable of evading any future U.S. anti-missile defenses. “I will speak about the newest systems of Russian strategic weapons that we are creating in response to the unilateral withdrawal of the United States of America from the Anti-Ballistic Missile Treaty,” Russian President Vladimir Putin said in March 2018 when introducing a slate of new nuclear weapons delivery systems, including hypersonic weapons.<sup>46</sup> These new systems, Putin said, are intended to “neutralize the threats posed by the deployment of the U.S. global missile defense system.” He added in September 2020 that “the U.S. withdrawal from the Anti-Ballistic Missile Treaty in 2002 forced Russia to start designing hypersonic weapons.”<sup>47</sup>

One of the systems Putin highlighted in March 2018 was Avangard, an HGV which can be launched from an ICBM and allegedly has “unlimited” range and the ability to render missile defense systems “useless.”<sup>48</sup> Avangard was tested<sup>49</sup> and likely first deployed in December 2019 on the SS-19 ICBM.<sup>50</sup> However, the system will probably be paired with the new Sarmat heavy ICBM once the missile is deployed, which, according to reports, will occur sometime in 2021.<sup>51</sup> The Avangard is believed to carry a nuclear warhead, though some Russian reports indicate it may also be capable of carrying a conventional payload.<sup>52</sup> Moscow has said that the HGV would be counted under the 2010 New Strategic Arms Reduction Treaty (New



**Russian President Vladimir Putin introduced a slate of new nuclear weapons delivery systems during a March 2018 address.** (Photo by Mikhail Svetlov/Getty Images)

START) due to its initial pairing with the SS-19 and possible future pairing with the Sarmat.<sup>53</sup> New START, which entered into force in 2011 and will expire in 2026, caps deployed ICBMs, submarine-launched ballistic missiles, and heavy bombers assigned to nuclear missions at 700, as well as deployed strategic nuclear warheads at 1,550.



**A display of the warhead of the Avangard hypersonic boost-glide vehicle from a video produced by the Russian Defense Ministry in 2018.** (TASS/TASS via Getty Images)

## Russian Hypersonic Weapons Programs

Program	conventional, nuclear, dual-capable	Description	Speed	Range (in kilometers)	Schedule
Avangard (Project 4202)	nuclear, possibly conventional	a hypersonic boost-glide vehicle launched from an ICBM (SS-19 or Sarmat)	Mach 20+	6,000	deployed in 2019
Kinzhal ("Dagger")	dual-capable	a hypersonic air-launched, short-range ballistic missile; compatible with the MiG-31K interceptor jet and the Tu-22M3 strategic bomber	Mach 10	2,000	reportedly entered trial deployment in 2017 and became operational in 2018
3M22 Tsirkon (or Zircon)	conventional, though may possibly become nuclear capable	a hypersonic cruise missile able to be launched from ship or sea	Mach 5–8	500–1,000	estimated deployment in 2023

Russia, like the United States, is also developing hypersonic weapons intended primarily for use in a regional context. It has fielded Kinzhal ("Dagger"), a hypersonic air-launched ballistic missile (ALBM), and is developing the Tsirkon (or Zircon), a hypersonic sea-launched cruise missile (SLCM).

It is not clear what novel threats Russia's new nuclear-armed hypersonic weapons pose to the United States. Russia's existing arsenal of long-range ballistic missiles can already circumvent U.S. missile defenses. Russian reports state that Kinzhal is designed to target U.S. or North Atlantic Treaty Organization (NATO) ship-based missile defense systems or land-based systems currently deployed in Romania and in the future in Poland.<sup>54</sup> Tsirkon is believed to be designed to help destroy carrier groups and land-based targets, such as command and control centers within a few kilometers of the coast.<sup>55</sup>

## China

China has long shied away from publicly disclosing information on its nuclear forces, and likewise, relatively little is known about Beijing's development of hypersonic weapons. Overall, China's motivations for pursuing these weapons appear to consist in part of defeating U.S. missile defenses and overpowering U.S. offensive weapons in the event of a major conflict in Asia.

The U.S. Defense Department, in its 2020 report on China's military power, described Beijing's pursuit of various technologies including HGVs as "necessary to counter" U.S. and other countries' ballistic missile defenses; intelligence, surveillance, and reconnaissance; and precision strike systems.<sup>56</sup> Tong Zhao, a senior fellow in the nuclear policy program at the Carnegie-Tsinghua Center for Global Policy, writes that, among the vast majority of Chinese experts, "the

## Chinese Hypersonic Weapons Programs

Program	conventional, nuclear, dual-capable	Description	Speed	Range (in kilometers)	Schedule
Dongfeng-17 (DF-17)	dual-capable most likely	a hypersonic glide vehicle on a road-mobile, medium-range ballistic missile	Mach 5–10	1,800–2,500	some reports indicate a deployment in 2020
Xing Kong-2 (Starry Sky-2)	nuclear	a hypersonic vehicle prototype; also described as a hypersonic waverider vehicle	Mach 6	unknown*	some reports indicate a deployment in 2025

\*no estimate or information publicly available



**The hypersonic glide vehicle system (DF-17) is seen during a military parade to celebrate the 70th Anniversary of the founding of the People's Republic of China at Tiananmen Square on October 1, 2019, in Beijing.** (Photo by Greg Baker/AFP via Getty Images)

ability to penetrate defensive systems is considered the most important feature of hypersonic weapons.”<sup>57</sup>

Many U.S. officials, on the other hand, claim that China seeks these capabilities to destroy U.S. aircraft carriers and other offensive forces (and their bases in the western Pacific) in the event of a war in Asia.

The programs underway in China include the Dongfeng-17 (DF-17), a medium-range ballistic missile system featuring a hypersonic glide vehicle that U.S. officials estimate has a range between 1,800 and 2,500km and that is slated to be deployed in 2020, according to some analysts.<sup>58</sup> The system can potentially reach speeds between Mach 5 and 10.<sup>59</sup> China has not stated whether the system will be conventional or nuclear, but the U.S. intelligence community has assessed that the DF-17 is dual-capable.<sup>60</sup>

Some reports speculate that the HGV from the DF-17 could also be paired with the DF-21 nuclear-capable medium-range missile, the DF-26 dual-capable intermediate-range missile, and the DF-41 dual-capable ICBM.<sup>61</sup> However, those reports are

unconfirmed. According to February 2020 testimony before the Senate Armed Services Committee, Gen. Terrence O’Shaughnessy, then-commander of U.S. Northern Command and North American Aerospace Defense Command, said that “China is testing an intercontinental range hypersonic glide vehicle—similar to the Russian Avangard—which is designed to fly at high speeds and low altitudes.”<sup>62</sup> But it is not known whether this new system would use the HGV from the DF-17 or develop a new HGV.

Some experts have questioned whether the DF-17 system poses a new threat relative to China’s existing long-range ballistic missiles, which fly at hypersonic speeds and, in the case of the DF-21 and DF-26, can carry a maneuvering reentry vehicle.<sup>63</sup>

China is also developing Xing Kong-2, or Starry Sky-2, which is a nuclear-capable hypersonic vehicle prototype.<sup>64</sup> This style of vehicle is known as a “waverider” for how it is able to derive lift from the shockwaves generated by its own hypersonic flight. The Xing Kong-2 reportedly was successfully flight tested in 2018.<sup>65</sup>

## Section III:

# Hypersonic Weapons and Strategic Stability

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The accelerating race between China, Russia, and the United States to develop and field new hypersonic weapons demonstrates that all three countries believe the weapons hold great military promise. As the hypersonic weapons competition continues to heat up, there has been significant debate about whether the weapons are poised to be a military game-changer or an evolutionary development that will not fundamentally alter the nature of conflict. But less attention is being paid to the ways in which the weaponization of this new technology could lead to new escalation dangers in a conflict, including to the nuclear level.

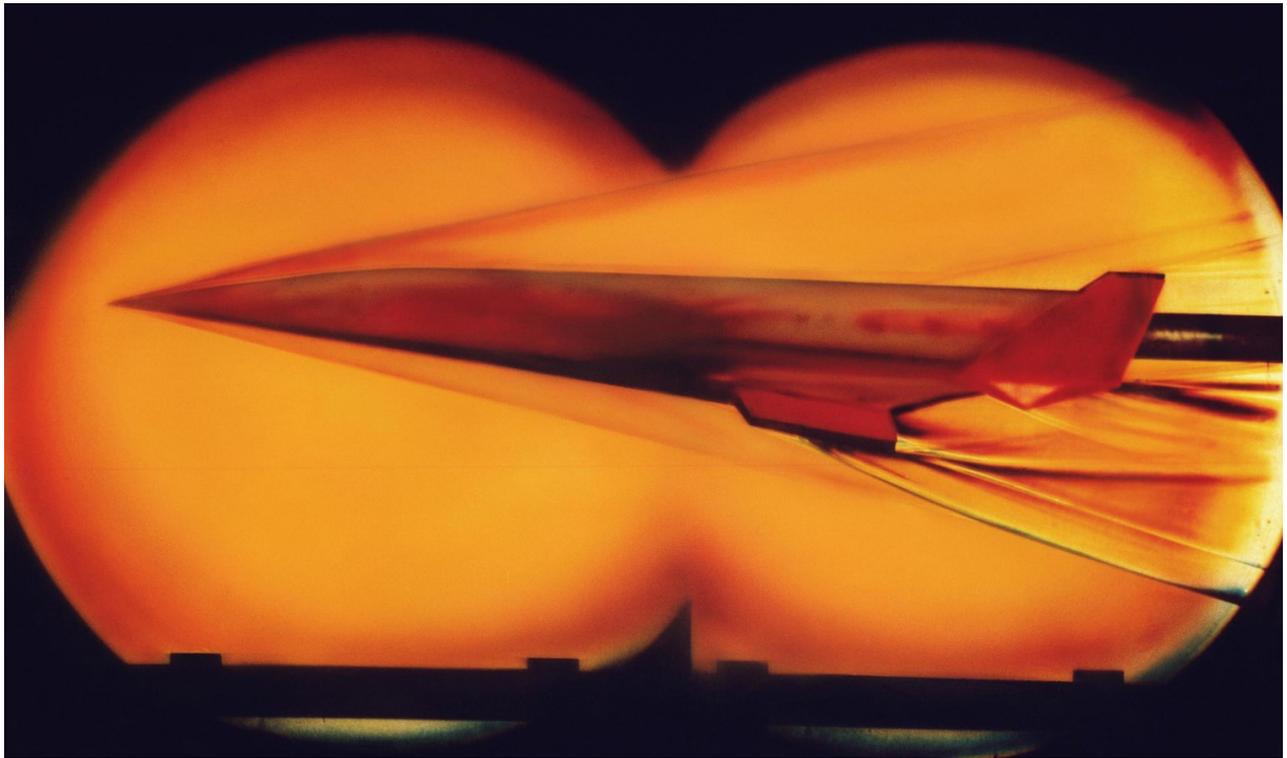
Sections I and II described the unique characteristics of hypersonic glide vehicles and cruise missiles, detailed how both proponents and skeptics view the benefits and downsides of the weapons relative to existing missile capabilities, and surveyed the types of and the rationale for the capabilities being pursued by the three major powers. This section will examine the possible risks the weapons, particularly HGVs, pose to strategic stability. Risks to stability include those emanating from target and warhead ambiguity, a reduction in response time, the potential ability to target mobile missiles, arms racing, and exacerbating threats posed by other emerging technologies.

This report defines “strategic stability” as consisting of crisis stability and arms race stability.<sup>66</sup> Crisis stability is defined as a condition in which nuclear powers are deterred from launching a nuclear first strike against one another. Arms race stability is defined as a condition in which two adversaries do not have an incentive to build up their strategic nuclear forces.

Heather Williams, a senior lecturer in the defense studies department and Centre for Science and Security Studies at Kings College London, helpfully expands the concept of strategic stability to also include the idea that legally-binding, widely practiced arms control agreements can help promote cooperation over competition.<sup>67</sup> Taken altogether then, strategic stability translates to a decrease in the chances of the outbreak of nuclear conflict or confrontation, whether intended or inadvertent.

### **Hypersonic weapons can prompt an escalation of a conflict due to target ambiguity.**

Conventional hypersonic weapons may be able to hold at risk targets that in the past have been immune from attack by conventional weapons. Indeed, as mentioned in section II, a primary U.S. rationale for acquiring these weapons is their perceived potential to increase the probability of destroying elusive targets such as road-mobile missiles.



**A model of a hypersonic glide vehicle is tested in a wind tunnel at NASA's Langley Research Center in Maryland on Dec. 10, 2009.** (Photo by NASA's Langley Research Center)

To the extent that hypersonic capabilities are “able to hold at risk targets that other weapon systems cannot,” explains Acton, “it could create certain additional risks of escalation. In this regard, attacks on command and control (which might be hard or buried), mobile non-nuclear missiles, and ASAT [anti-satellite] weapons... could carry particular risks of escalation.”<sup>68</sup>

This escalation risk is further exacerbated when the target is a site that houses both conventional and nuclear delivery systems or dual-use command-and-control systems. “A state could mistakenly believe that its nuclear forces were under attack when its conventional forces were really the target (target ambiguity),” Acton writes. “This situation could arise, for instance, if a state’s nuclear and conventional assets were ‘entangled’ because of dual-use command-and-control systems.”<sup>69</sup>

For instance, there is uncertainty about whether Moscow has deployed nuclear warheads to its Kaliningrad enclave on the Baltic Sea, which is home to a variety of dual-use delivery systems including aircraft and short-range ballistic missiles.<sup>70</sup> An attack on sites like these that intermix nuclear and conventional capabilities “could blur the distinction between conventional and nuclear war,” writes Wilkening. “This increases the chance that the attack will be misperceived as an attempt to degrade

a country’s nuclear, as opposed to conventional, military forces,” which might trigger a nuclear response.<sup>71</sup>

### **Hypersonic weapons can prompt an escalation of a conflict due to warhead ambiguity.**

Ambiguity about whether a hypersonic weapon is carrying a conventional or nuclear payload could trigger a nuclear-armed country, targeted by a conventional attack, to launch its nuclear weapons in response. Of course, this risk is not unique to hypersonic weapons—it is also a risk associated with dual-capable subsonic cruise missiles and dual-capable ballistic missiles. But the danger could be greater with hypersonic weapons due to their unique flight profile.

The risk warhead ambiguity poses to stability is most acute when a country fields nuclear and conventional variants of the same missile. China and Russia are deploying such dual-capable missiles, including HGVs. The use of such weapons in a great-power conflict could lead to inadvertent escalation. “Warhead ambiguity will remain a feature of any future landscape involving the deployment of multiple hypersonic weapons, as a defender will never be certain that an enemy’s assault is entirely non-nuclear,” writes Michael Klare, professor emeritus of peace and world-security

studies at Hampshire College and senior visiting fellow at the Arms Control Association. “With as little as five minutes to assess an attack—the time it would take a hypersonic glide vehicle to traverse 2,000 miles—a defender would be understandably hard pressed to avoid worst-case assumptions.”<sup>72</sup>

Concerns about warhead ambiguity prompted Congress in 2007 to block a request by the George W. Bush administration to modify some Trident II submarine-launched ballistic missiles to carry conventional warheads. Lawmakers raised concerns that Russia might interpret the launch of a conventional Trident missile as a nuclear attack.<sup>73</sup>

**Hypersonic weapons can prompt an escalation of a conflict due to their high speeds, which can lead to a reduction in response time and the potential for more successful strikes against time-critical targets.**

A risk to stability associated with the extreme speed of new hypersonic weapons is that they could reduce the amount of time a targeted country has to respond to a strike involving the weapons. During this compressed timeline, a country must first detect a strike, try to fully assess the kinds of weapons involved, debate the appropriate response, distribute any orders for a retaliatory strike, and then see those orders carried out—an exceedingly difficult proposition.

The time crunch will increase pressure on decision-makers and heighten the risk of inadvertent escalation. With less time to fully understand the nature and the scope of the attack, decision-makers may veer towards overestimating the attack, especially if they view the very forces their country relies on for retaliation against a first strike to be under imminent threat. A reduction in decision time exacerbates the target and warhead ambiguities problems. Less response time translates to less time to determine whether an incoming hypersonic weapon carries a nuclear or conventional payload and less time to attempt to pinpoint the weapon’s final destination.

The Rand Corporation has estimated that “for adjacent enemies within a 1,000km range, a hypersonic missile traveling at ten times the speed of sound could cover that distance and reduce response times to about six minutes.”<sup>74</sup> Over intercontinental ranges, the compressed timeline may be less of a concern, for the time it takes for hypersonic weapons to travel that greater distance is roughly comparable to the time it takes for ballistic missiles to do the same, as noted by Tracy and David Wright, a research affiliate in the department of nuclear science and engineering at the Massachusetts Institute of Technology.<sup>75</sup>

Ryan McCarthy, then-secretary of the Army, in a 2020 interview compared hypersonic weapons to the

Pershing II medium-range, nuclear-armed ballistic missiles that the United States deployed in Europe in the 1980s. The missiles, which could strike Moscow in a matter of minutes, were viewed as uniquely destabilizing, and, following the ascension of Mikhail Gorbachev to power in the Soviet Union and massive anti-nuclear protests in the United States and Europe, were ultimately eliminated per the terms of the INF Treaty. “If you don’t have essentially the type of almost artificial intelligence-like capabilities because of the speed at which the munition can travel, you can’t find it, sense it, or shoot it because it’ll be there within a couple of minutes,” McCarthy said. “And it could send a very strong message, or it can confuse people, too. And you could end up in an escalatory type of situation.” He added, “It’s going to change warfare.”<sup>76</sup>

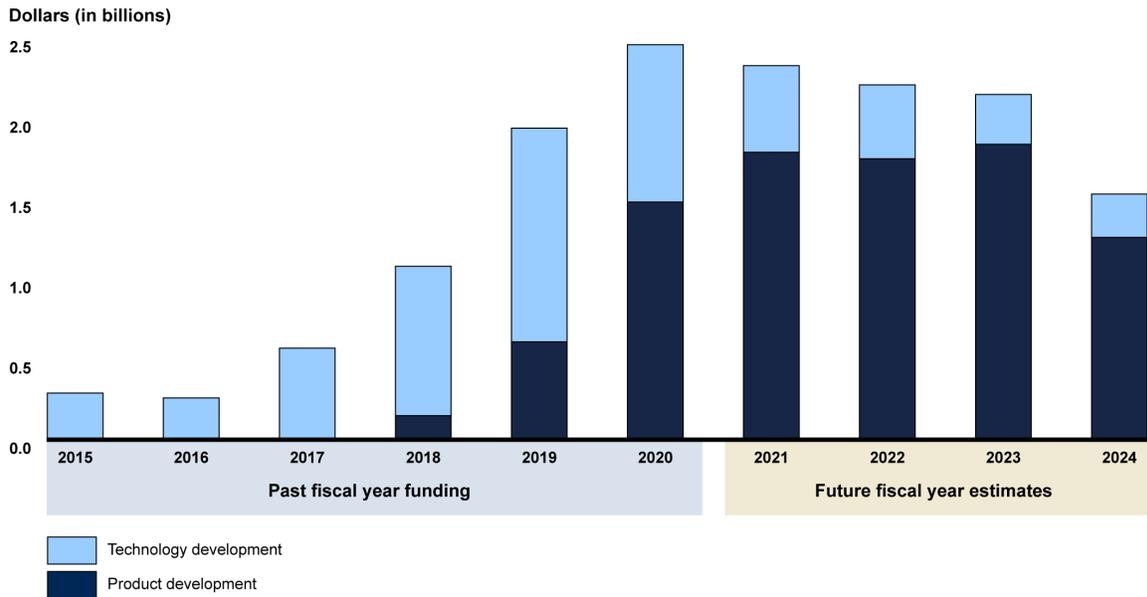
An additional area of concern posed by the speed of conventional HGVs and HCMs— and related to the target ambiguity problem—are Chinese and Russian perceptions of these fast weapons as capable of undermining the survivability of their nuclear forces. As noted in section II, the Defense Department has cited engaging mobile missiles in particular as a rationale for hypersonic weapons. Eric Gomez, director for defense policy studies at the Cato Institute, has written that targeting these capabilities “would...make China’s nuclear forces more vulnerable to attack.”<sup>77</sup> Therefore, using hypersonic weapons to target dual-capable Chinese mobile missiles and their



**In a January 2020 interview, Ryan McCarthy, then-secretary of the Army, warned of the speed of hypersonic weapons and argued that they will “change warfare.”**

(Photo by Chip Somodevilla/Getty Images)

## Hypersonic Weapon-related and Technology Development Total Reported Funding by Type of Effort from Fiscal Years 2015 through 2024, in Billions of Then-Year Dollars



(Graphic by United States Government Accountability Office)

supporting air-defense and command and control capabilities deep inside Chinese territory, though perhaps appealing if the goal is to overwhelm China in a conventional conflict, runs the risk of inadvertent escalation to the nuclear level.

### Hypersonic weapons risk further upsetting the already tense offense-defense interrelationship and perpetuating a competitive cycle of one-upmanship.

“Hypersonic weapons of all types will stimulate an intense offense-defense competition—a classic form of arms-race instability,”<sup>78</sup> writes Wilkening. This competition occurs when the acquisition of offensive weapons that pose a distinctive new threat to an adversary typically results in efforts by that state to acquire additional defenses against those weapons, leading to the introduction of ever-more capable offensive weapons.

This competition is arguably already underway. One of the main motivations behind Chinese and Russian development and deployment of new hypersonic weapons is to possess weaponry capable of evading U.S. missile defenses. “Hypersonic missiles are being developed to bypass perceived U.S. missile defense capabilities,” Vice Adm. Jon Hill, director of the Missile Defense Agency, told the Senate Armed Services Committee in June 2021.<sup>79</sup>

Meanwhile, the United States cites Chinese and Russian development of HGVs and HCMs as a justification for building up its own hypersonic weapons and missile defenses to guard against these weapons. The United States is “working on” deploying hypersonic capabilities, “but we are behind China and Russia,” said Sen. Jim Inhofe (R-Okla.), then-acting chairman of the Senate Armed Services Committee, in 2018.<sup>80</sup> Lt. Gen. Duke Richardson, military deputy to the assistant secretary of the Air Force for acquisition, technology, and logistics, echoed this remark in June 2021, saying that “we are catching up very, very quickly” and “we are getting after it.”<sup>81</sup>

But this raises the question of when is enough, enough? Do leaders in Washington, Beijing, and Moscow have a clear picture of where the current race to acquire hypersonic weapons is headed or should end? Is there a rationale other than speeding ahead in order to come out on top?

There is also a financial cost to the race. Congress appropriated in fiscal year 2021 a total of about \$2.2 billion for the six existing hypersonic weapons programs at that time and \$130 million for hypersonic missile defense. The GAO estimates the cost of hypersonic weapons and technology development efforts to be \$15 billion from fiscal years 2015 through 2024. Funding has increased substantially across those years, “including an increase of approximately 740

percent between fiscal years 2015 and 2020.” These expenditures are just for the prototype phase and do not include the cost to produce and sustain operational weapons “because DOD has not yet budgeted for them.”<sup>82</sup> Two programs in the prototype phase have already “experienced either formal cost increases or have submitted budget estimates that exceed their previous rough order-of-magnitude estimates.”<sup>83</sup>

**Hypersonic weapons could exacerbate the stability risks posed by other advancing technologies of concern, such as counterspace and cyber capabilities.**

The risks posed by the development and the deployment of hypersonic weapons must be assessed alongside the weaponization of other emerging technologies, such as artificial intelligence (AI), cyber, and autonomy. “Strategic stability no longer rests solely in the nuclear realm, and states will operate in other domains where they have a perceived advantage,” writes Williams.<sup>84</sup> To consider HGVs and HCMs in isolation fails to understand how technological advancement across multiple areas in the offensive and defensive weapons space can create an overall alarming picture of a nation gaining

a marked edge over its competitors. In such a case, instability could arise as some countries view their military capabilities as no longer sufficient and race to try to keep pace or get ahead in the competition.

“My real concern about arms racing right now is not a hypersonic arms race per se, but it’s the arms race when all these technologies are kind of being developed at the same time, and we need to think through the possible interconnectivity that could be produced and what could be a pretty serious arms race if we’re not careful,” notes Hruby, specifically mentioning the simultaneous weaponization of cyberspace, space, and AI.<sup>85</sup>

For example, Klare has highlighted the risks that may emerge in a world in which the nuclear powers possess hypersonic weapons and begin to depend on AI to assess incoming attacks and determine an appropriate counterattack. He warns that this convergence of advanced technologies may lead to the possibility of “a ‘flash war’ erupting when machines misinterpret radar signals and initiate catastrophic, possibly nuclear, responses.”<sup>86</sup>

Taken together, the weaponization of these advanced technologies could undermine—or appear to undermine—the survivability of nuclear forces more effectively than any one technology could alone.

## Section IV:

# Hypersonic Arms Control Options

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**G**iven the potential risks to stability posed by hypersonic weapons, arms control is a viable tool that should be used to mitigate these risks. For the purposes of this report, arms control is defined as a form of mutual agreement(s) or commitment(s) through which states might reduce nuclear risks. The benefits of arms control include avoiding an action-reaction arms race; reducing incentives to preemptively strike adversary military forces, including nuclear forces; lowering the chances of inadvertent escalation; and saving money.<sup>87</sup>

“There are no ready solutions” for mitigating the potential instabilities created by hypersonic weapons, writes Wilkening. Though he argues for the United States to field large numbers of hypersonic weapons, Wilkening also states that it “behooves the major nuclear powers to think carefully about how to mitigate potential instabilities” presented by the weapons “before they become truly unmanageable.”<sup>88</sup>

Experts in recent years have begun to explore various possible arms control options ranging from confidence-building measures to bans or limits on certain types of hypersonic weapons. Some of the options would be applicable to China, Russia, and the United States, while others may only be relevant for two of the major powers. In addition, there are steps that the United States could take unilaterally to minimize escalatory risks associated with these weapons.

The pursuit of hypersonic arms control is increasingly important as these weapons transition from an “emerging technology” and are deployed in greater numbers and on more diverse delivery platforms. Chinese and Russian HGVs are already on the scene, and the United States plans to begin deploying its own hypersonic capabilities starting next year. It therefore would be prudent to pursue

arms control before the weapons are fielded in larger numbers by the three major powers and present a greater threat to strategic stability.

In addition, two of those powers have already expressed interest in raising hypersonic weapons as a topic in an established dialogue on strategic stability. The United States and Russia resumed this bilateral dialogue in July 2021 in order to begin, in part, initial discussions on potential future arms control arrangements, and both countries have suggested an intent to address hypersonic weapons in this setting.<sup>89</sup> Such an opportunity should not go to waste.

### Confidence-Building Measures

Confidence-building measures refer to “reciprocal actions taken to reduce the dangerous consequences of particular weapons systems without formal treaties.”<sup>90</sup> These measures are meant to promote transparency and stability and can help to lay the groundwork and foster a more conducive environment for a binding agreement.

Acton and Wilkening have each suggested variations of basing restrictions for hypersonic weapons. The latter has posited a confidence-building measure in which conventional and nuclear forces are not co-located at the same sites. Acton, meanwhile,



**Members of the AGM-183A Air-launched Rapid Response Weapon (ARRW) test team make final preparations prior to a captive-carry test flight of the prototype hypersonic weapon at Edwards Air Force Base, Calif., on Aug. 8, 2020.**

(Photo by U.S. Department of Defense)

has suggested that Russia and the United States could agree, on a voluntary basis, to forbid the basing of any heavy bombers not covered already by New START, such as the U.S. B-1B bomber which may carry ARRW, outside of national territory.<sup>91</sup> Wilkening has also suggested not using systems previously associated with nuclear weapons to launch conventional HGVs and HCMs. This option would only be applicable to Russia and China since the United States is only currently developing conventional hypersonic weapons.

In addition, there could be confidence-building measures that aim to increase transparency through information sharing and demonstrations of the systems. Acton has proposed data exchanges on acquisition and/or deployment of precision guided missiles, such as HGVs and HCMs, as well as the exchange of observers at military exercises involving these weapons.<sup>92</sup> Williams has similarly suggested that China, Russia, and the United States hold military-to-military talks on hypersonic weapons and conduct mutual demonstrations of their systems.<sup>93</sup>

## Bans

“If strategic stability is the paramount goal,” Wilkening writes, “then banning all short-time-of-flight counterforce weapons, including ballistic

missiles, would make sense.”<sup>94</sup> In the absence of such weapons, conventional and nuclear attacks would unfold at a slower pace, lowering the chances of miscalculation and unintended escalation. Yet, Wilkening notes, this route seems highly unlikely to gain traction as eliminating ballistic missiles is an unpalatable idea among all three countries given Chinese and Russian reliance on ICBMs.

Pranay Vaddi, a former fellow in the nuclear policy program at Carnegie, and Acton have suggested a prohibition on the fielding of long-range, air-launched ballistic and boost-glide vehicles, such as Russia’s Kinzhal and the U.S. ARRW, except when fielded on either New START treaty-accountable heavy bombers or nonaccountable short-range tactical aircraft.<sup>95</sup> They also argue that nuclear-armed, long-range sea-launched boost-glide vehicles should be labeled as a new kind of strategic offensive arm under New START if deployed and should not be deployed on ships or submarines that carry conventional variants of that kind or long-range nonnuclear sea-launched cruise missiles.<sup>96</sup>

There is a robust debate among experts about the merits of a moratorium or a ban on the testing of hypersonic weapons. “A hypersonic test ban would be strong arms control,” writes Mark Gubrud, a physicist at the University of North Carolina. “No nation would

base preemptive strategic attack plans on weapons that have not been thoroughly tested, debugged, and proven reliable.<sup>97</sup> While Gubrud argues a hypersonic test ban would be verifiable, Acton has noted that there is no clear dividing line between boost-glide vehicles and terminally guided ballistic missiles, such as the Chinese DF-21, which maneuvers to its target after re-entering the atmosphere. “If all maneuvering re-entry vehicles are banned,” Acton said, “China will never sign up.”<sup>98</sup>

## Limits

Mitigating the risks posed by hypersonic weapons could also take the form of bilateral or trilateral agreements that limit the systems.

Williams has developed ideas for limiting HGVs in particular, including an agreement that caps the number of such weapons in each country’s arsenal, similar to the limits contained in New START.<sup>99</sup> She has also proposed adaptive asymmetric limits.<sup>100</sup> Such an agreement between the United States and Russia, for example, might contain an overall limit of 1,000 nuclear warheads on 600 delivery vehicles, to include HGVs, nonstrategic nuclear weapons, and strategic delivery vehicles. If a country wanted to increase the number of HGVs such that it would exceed the agreement’s limits, then it would need to further reduce its nuclear forces to compensate.

Vaddi and Acton have put forward suggestions on how to fold U.S. and Russian HGVs into a follow-on treaty to New START, which expires in 2026. They argue that a follow-on agreement should include a focus on “managing technological advances in delivery systems.”<sup>101</sup> Vaddi and Acton suggest that the central limits of a follow-on treaty to New START should cover intercontinental-range, ground-launched, boost-glide missiles (such as Russia’s already deployed Avangard), whether nuclear or conventional, as they constitute new kinds of strategic offensive arms. The United States “is focused on the development of nonnuclear boost-glide weapons with shorter ranges, but it has conducted flight tests of intercontinental-range systems, which also may not be captured by New START’s limits,” they write. Therefore, “Russia is concerned that U.S. [intercontinental-range, ground-launched, boost-glide missiles], whether nuclear or conventionally armed, could threaten its nuclear forces,” making limits on this kind of system important for mitigating such concerns.<sup>102</sup>

Vaddi and Acton also encourage the inclusion of a stronger “new kinds of strategic offensive arms” provision that would cover nuclear and nonnuclear weapons of strategic range that emerge after such a treaty’s entry into force.<sup>103</sup> Such a provision would be important as research and development of long-range HGVs march forward. Some of the arms they propose

be considered as a new kind include nuclear-armed submarine-launched boost-glide missiles and air-launched boost-glide missiles with ranges greater than 4,500km.

Klare proposes commencing talks on a new agreement that, like the now defunct INF Treaty, would set a limit on all deployed hypersonic weapons, whether air, sea, or ground launched, or limit their deployed numbers below a certain threshold so as to minimize fears of a disarming first strike. Confidence-building measures such as “information-sharing on the range and capabilities of proposed weapons and protocols intended to differentiate conventionally armed hypersonic weapons from nuclear-armed ones, so as to reduce the risk of warhead ambiguity” could help to pave the way for a formal agreement, he writes.<sup>104</sup>

## Unilateral U.S. Measures

There are also steps that the United States could take unilaterally to minimize escalatory risks. For example, the rationale for the Army’s LRHW program is arguably the weakest among current U.S. development programs. The program faces difficult and potentially unanswerable questions such as where to base the missiles.<sup>105</sup> The weapon is controversial within the Pentagon. Plus, the weapon poses many of the stability risks identified in the previous section given its range and speed and the fact that the United States does not currently field any ground-launched missiles with a range beyond 500km. One option would be for the United States to cancel the LRHW program. The Biden administration has already proposed \$226 million less for the program in fiscal year 2022 than the Trump administration’s projection for it last year and relocated those funds in part towards supporting the development of other shorter-range ground-launched missile capabilities.

## Getting to the Negotiating Table

None of the above cooperative arms control concepts will gain traction, let alone become the basis for agreements between nations with the capability to develop and deploy hypersonic weapons, in the absence of an active and productive dialogue and ultimately negotiation about hypersonic weapons.

Consequently, it is vital for senior officials from Russia and the United States, as well as China, to engage in professional, regular exchanges of views on the nature of hypersonic weapons technologies, their purposes, and each country’s respective perceptions of the potential risks to stability and security these capabilities may pose.

Hypersonic weapons—and potential arms control measures relating to them—should be one part of the U.S.-Russian strategic stability dialogue endorsed



**During their June 16 summit in Geneva, U.S. President Joe Biden (L) and Russian President Vladimir Putin (R) agreed to relaunch a strategic stability dialogue.** (Photo by Peter Klauzner—Pool/Keystone via Getty Images)

by Presidents Joe Biden and Vladimir Putin during their June 16 summit and restarted in July 2021. According to officials from the two countries, these discussions may include the interrelated topics of strategic and nonstrategic nuclear weapons and their delivery systems, advanced missile defense systems that can negate each side's retaliatory potential, and conventional prompt strike weapons that can potentially hold strategic targets, including military command and control centers, at risk.<sup>106</sup>

According to Biden and Putin's joint summit communique, the talks are for "ensuring predictability," reducing the risk of nuclear war, and setting the stage "for future arms control and risk reduction measures."<sup>107</sup> Biden added at a press conference after the summit that the dialogue would

"work on a mechanism that can lead to control of new and dangerous and sophisticated weapons that are coming on the scene now that reduce the times of response, that raise the prospects of accidental war."<sup>108</sup> This dialogue, therefore, is a natural venue in which to hold initial discussions aimed at addressing new hypersonic capabilities.

A similar bilateral strategic stability dialogue involving senior U.S. and Chinese diplomatic officials, military officers, and technical experts could help to dispel misconceptions and improve mutual understandings about each nation's strategic and nonstrategic nuclear forces, their advanced missile defense systems, and hypersonic weapons, as well as to exchange views about how they each perceive these weapons' ability to affect mutual security.

## Section V:

# Recommended Action Items for Congress

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**A**s the 117th Congress scrutinizes the Defense Department’s plans to develop and field new hypersonic weapons and considers adjustments to the programs, there are numerous steps lawmakers should take to improve their understanding of the department’s motivations for acquiring the weapons, procurement plans and anticipated costs, concept of operations for their deployment, potential alternatives, and plans to mitigate the potential strategic stability risks the weapons pose. Below are six recommended action items for Congress.

### **1. Hold in-depth hearings on the Defense Department’s plans for the development of hypersonic weapons.**

The House and Senate Armed Services Committees should hold hearings on the Pentagon’s hypersonic weapon development plans in light of the many unanswered questions and concerns that have been raised about these plans. The areas of focus should include:

- The rationale and specific mission needs for acquiring HGVs and HCMs, to include a clearly defined concept of operations and the intended targets for the weapons;
- The need for each service to have its own hypersonic weapon;
- The specific schedules for each development program, including flight testing;
- The planned production quantities of the weapons;
- Whether, and if so how, China’s and Russia’s hypersonic weapon development programs pose threats that are additive to their existing missile capabilities;

- The risks to stability posed by hypersonic weapons; and
- The degree to which the Pentagon considers the escalation risks the weapons pose as a key input in decisions about acquiring the weapons.<sup>109</sup>

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### **2. Mandate an independent technical assessment of the Pentagon’s rationale for developing offensive and defensive hypersonic weapons, the technical feasibility of achieving the objectives set out for the weapons, and the feasibility of alternative capabilities to meet these objectives.**

U.S. defense officials have offered varying rationales for the Pentagon’s pursuit of new hypersonic weapons, to include the need for a weapon capable of evading missile defenses and the desire to keep pace with competitors. An independent technical assessment would prove valuable in ensuring the Defense Department has a clear and specific motivation for U.S. development and deployment of HGVs and HCMs and avoids the acquisition of redundant capabilities. In addition, Congress could request that the assessment evaluate whether hypersonic weapons will be able to fulfill the mission

set identified by the Pentagon, whether other capabilities could do so more cost effectively and in a way that is less destabilizing, and to what extent Chinese and Russian hypersonic capabilities increase the threat to the United States above their existing military capabilities.

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**3. Mandate an assessment by the Congressional Budget Office (CBO) on the financial costs of the Pentagon's new hypersonic weapon development plans and the costs of potential alternative capabilities to fulfill the objectives set out for the weapons.**

The projected cost of hypersonic weapons is highly uncertain. Two programs, ARRW and CPS, have already seen steep costs increases: ARRW saw a nearly 40 percent increase in its total costs within the first year, and CPS had a budget that nearly doubled between fiscal years 2019 and 2020.<sup>110</sup> The GAO notes that current rapid hypersonic weapon prototyping programs are “not necessarily planning for sustainment costs” and that “the structure of these initial hypersonic weapon programs produces additional uncertainties in terms of expected costs of full production of the resulting weapons.”<sup>111</sup> In addition to assessing the cost of existing programs across a range of potential production quantities, CBO should also evaluate the costs of other potential capabilities that would fulfill the objectives envisioned for HGVs and HCMs.

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**4. Condition funding for the Army's LRHW program on the Pentagon addressing the rationale and strategy for procuring, basing, and operating the weapon.**

Given the concerns about the Army's LRHW program, Congress at a minimum should condition funding for the weapon on the Defense Department taking steps to address these concerns. Congress could accomplish this by prohibiting the procurement or deployment of (but not necessarily further research and development on) the weapon until the Pentagon conducts an analysis of alternatives, details realistic basing options, and provides a plan for mitigating risks to stability.<sup>112</sup> Congress could also condition procurement or deployment on a U.S. ally or partner agreeing to host the weapons on their territory.

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**5. Require a U.S. intelligence assessment to assess how the ability to conduct prompt, long-range strikes against high-value targets would be perceived by near-peer adversaries and rogue states, how they would likely respond to such deployments, how such strikes could lead to unintended escalation in a conflict, and options to mitigate crisis instability risks.**

The Russian Embassy in the United States said in July 2021 Moscow plans to respond to any “destabilizing” future potential deployment of U.S. hypersonic weapons in Europe. “Their short flight time would leave Russia [with] little to no decision time and raise [the] likelihood of inadvertent conflict” wrote the embassy on Twitter.<sup>113</sup> Of course, Russia is fielding its own hypersonic weapons and other long-range missiles that threaten stability in Europe. But an action-reaction missile race would make Europe less secure.

The Defense Department “is keenly aware of and takes seriously Congressional concerns that hypersonic strike systems may raise significant strategic stability and policy questions,” Melissa Dalton, acting assistant secretary of defense for strategy, plans, and capabilities, told the House Armed Services Committee a few months previously in April 2021.<sup>114</sup> But the department has yet to explain how it views these concerns and the steps it is taking to mitigate them. Concerns about risks to stability have in the past prompted Congress to restrict funding for other previous prompt long-range strike programs.<sup>115</sup>

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**6. Engage officials from the State Department on possible avenues for future arms control on HGVs and HCMs.**

Congress—in particular the House and Senate Armed Services Committees, the House Foreign Affairs Committee, and the Senate Foreign Relations Committee—should seek to hold dialogue with officials from the State Department on possible avenues for future arms control on HCMs and HGVs. This dialogue would help to inform Congressional decision-making on funding for the weapons and the Executive Branch's thinking about how to use arms control to reduce the risks the weapons pose.

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The Biden administration has signaled its intent to march forward with the development of hypersonic weapons capabilities. The first U.S. hypersonic weapon is scheduled to be fielded next year, while China and Russia have each deployed such weapons over the previous two years. Hypersonic weapons, in particular HGVs, are on the field.

Congress, however, should resist the pull to rubber-stamp the Defense Department's accelerated development approach. There remain numerous questions concerning the rationale for, escalatory and instability risks of, costs of, and potential alternatives to hypersonic weapons that have thus far gone unasked or unanswered. It is time—in fact, past time—for Congress to demand these answers before the military begins fielding the weapons in possibly great numbers.

## Past U.S. Congressional Legislation

FY 2016	Hypersonic Missile Defense	Requests a concept definition of a space-based ballistic missile intercept layer to add to the ballistic missile defense system that provides, among other things, additional defensive options against hypersonic glide vehicles (Sec. 1685)
	Hypersonic Weapons	Requires the development of a plan for integrating advanced technologies, such as hypersonic strike systems, into broader war games to improve socialization with the warfighter and the development and experimentation of various concepts for employment by the armed forces (Sec. 240)
FY 2017	Hypersonic Missile Defense	<ul style="list-style-type: none"> <li>• Authorizes the Defense Department to conduct a pilot program for various new capabilities, such as defense against hypersonic missiles, including sensors (Sec. 884)</li> <li>• Requires a review on U.S. missile defeat capability, to include the defeat of hypersonic glide vehicles (Sec. 1684)</li> <li>• Directs the director of the Missile Defense Agency to serve as the lead for the development of a capability to counter hypersonic boost-glide vehicle capabilities and conventional prompt global strike capabilities; requires a report on the architecture and sensors needed to detect hypersonic threats and on the military capabilities and capability gaps related to the threat posed by hypersonic boost-glide vehicles and maneuvering ballistic missiles (Sec. 1687)</li> </ul>
FY 2018	Hypersonic Weapons	Redesignates the joint technology office as the “Joint Hypersonics Transition Office,” which is tasked with expediting the testing, evaluation, and acquisition of hypersonic weapon systems and coordinating the development of such systems (Sec. 214)
FY 2019	Hypersonic Missile Defense	<ul style="list-style-type: none"> <li>• Accelerates the hypersonic missile defense program of the Missile Defense Agency; requires the deployment of the program in conjunction with a space-based missile defense sensor program; requires a report covering the cost of such an acceleration, the technical requirements and acquisition plan, and the testing plan (Sec. 1689)</li> <li>• Requires a validated requirement from the Pentagon for ground-, sea-, or air-launched conventional prompt global strike hypersonic capabilities; requires a report that describes the plan for a conventional prompt global strike weapon system and details the level of ambiguity and misinterpretation risk relating to this system (Sec. 1698)</li> </ul>
	Hypersonic Weapons	Requires a report directly comparing the capabilities of the United States in emerging technology areas, including hypersonic weapons, to the capabilities of U.S. adversaries in such areas (Sec. 247)

FY 2020	Hypersonic Missile Defense	<ul style="list-style-type: none"> <li>Requires the Defense Secretary to redesignate all strategies, policies, programs, and systems to reflect that the missile defense programs of the United States defend against ballistic, cruise, and hypersonic missiles in all phases of flight (Sec. 1681)</li> <li>Requires the development of a hypersonic and ballistic missile tracking space sensor payload (Sec. 1683)</li> </ul>
	Hypersonic Weapons	<ul style="list-style-type: none"> <li>Authorizes the Joint Hypersonics Transition Office to enter into agreements with institutes of higher education to provide foundational and applied hypersonic research, development, and workforce support (Sec. 216)</li> <li>Expresses a Sense of Congress, in relation to hypersonic weapon systems, prohibiting any FY 2020 funds for a submarine launched conventional prompt global strike capability unless such capability is transferable to a surface-launched platform (Sec. 1697)</li> </ul>

FY 2021	Hypersonic Missile Defense	<ul style="list-style-type: none"> <li>Requires a classified assessment on the threats posed by cruise, hypersonic, and ballistic missiles to current and planned integrated air and missile defense technologies and force structure (Sec. 155)</li> <li>Requires the development and the procurement of a hypersonic and ballistic missile tracking space sensor payload (Sec. 1645)</li> </ul>
	Hypersonic Weapons	<ul style="list-style-type: none"> <li>Requires the improvement of ground-based test facilities used for hypersonic capabilities and an increase of the rate at which hypersonic capabilities are flight tested; requires from the Air Force a strategy and plan for fielding air-launched and air-breathing hypersonic weapons capabilities (Sec. 222)</li> <li>Establishes a steering committee on emerging technology and emerging threats, which includes hypersonic weapons, and tasks the committee with developing a strategy for the concept and capability development and the technology investments in emerging technologies that are needed to maintain the technological superiority of the United States military and assessing the advances in emerging technology of U.S. adversaries (Sec. 236)</li> <li>Requires a report from U.S. Indo-Pacific Command on the resources, including investments in hypersonic missiles, needed for the Pacific Defense Initiative to achieve measurable progress towards its objectives in the region (Sec. 1251)</li> <li>Requires the integration of conventional prompt strike technologies on Zumwalt-class destroyers; requires a report on strategic hypersonic weapons, to include an assessment of how escalation risks would be addressed, potential target sets, and whether hypersonic weapons should be deployed on both submarines and surface combatants (Sec. 1671)</li> </ul>

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# Arms Control Association

**The Arms Control Association (ACA)**, founded in 1971, is a national nonpartisan membership organization dedicated to promoting public understanding of and support for effective arms control policies. Through its public education and media programs and its magazine, *Arms Control Today* (ACT), ACA provides policy-makers, the press and the interested public with authoritative information, analysis and commentary on arms control proposals, negotiations and agreements, and related national security issues. In addition to the regular press briefings ACA holds on major arms control developments, the Association's staff provides commentary and analysis on a broad spectrum of issues for journalists and scholars both in the United States and abroad.

The debate concerning hypersonic weapons has gained increased attention in recent years as the United States has poured billions of dollars—and plans to pour billions more—into accelerating the development of hypersonic weapons and as China and Russia make headway in developing and deploying their own such weapons. The Pentagon is funding no less than eight prototype hypersonic weapons programs with the aim of fielding an initial capability of at least some of those by 2022.

This report outlines the scope of the unanswered questions about the case for hypersonic weapons, details the underappreciated risks to stability posed by the weapons, assesses the viability of arms control as a tool to reduce these risks, and suggests recommended action items for Congress to better its understanding about the Pentagon's plans for the weapons, eliminate potential redundancies in weapons capabilities, and mitigate stability risks.

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