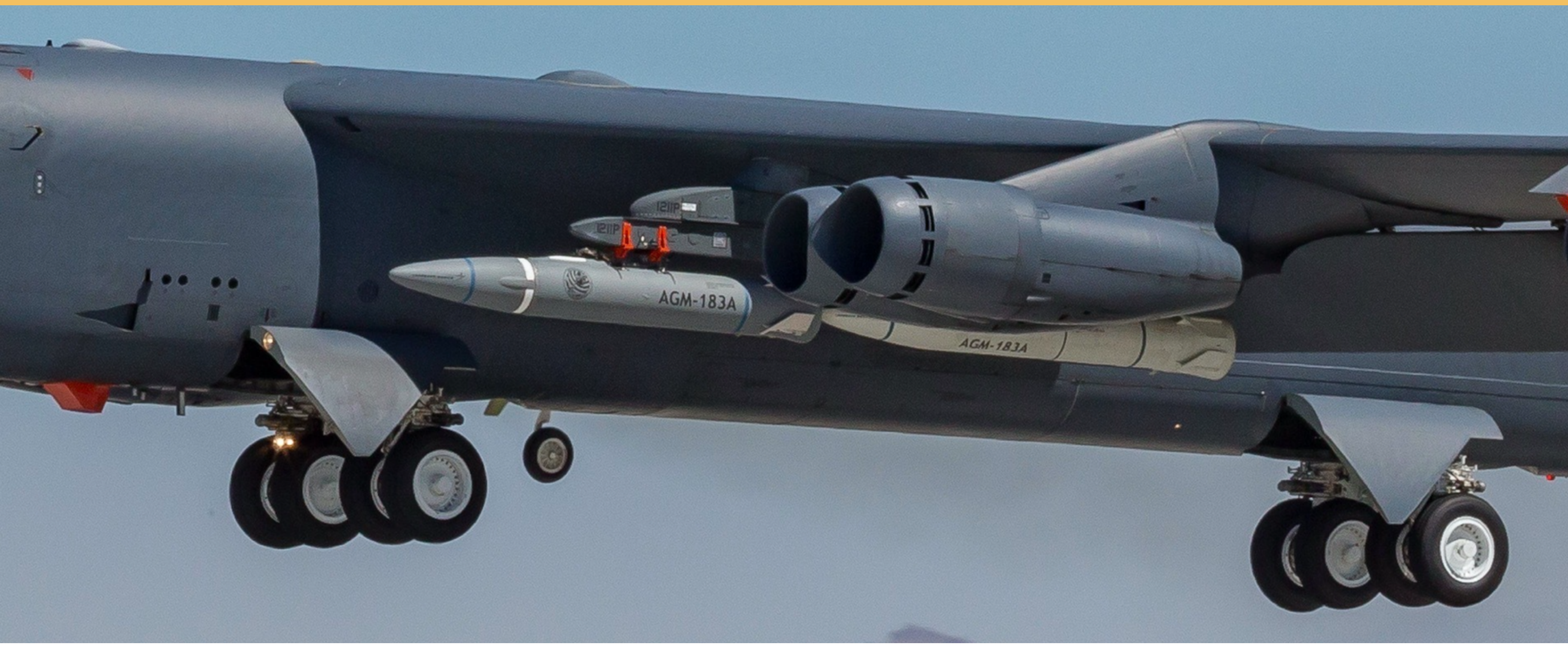

NOVEMBER 2, 2020

Adapting to the Hypersonic Era

By **Ian Williams**

Since the late-1940s, the United States has used forward-based forces to deter military aggression against its allies and interests. These forces complicate an adversary's ability to achieve a quick, *fait accompli* win, raising the threshold for states to engage in conflict. However, the emergence of aerial hypersonic weapons—specifically, these systems' combination of speed, maneuverability, and atmospheric flight—challenges traditional U.S. approaches to regional deterrence and stability. Conventional hypersonic strike weapons undermine deterrence by complicating early-warning and increasing the vulnerability of forward-based forces to surprise attack below the nuclear threshold.

Nevertheless, history shows that adaptation to strategically disruptive technologies is possible. Just as the world mitigated the most destabilizing aspects of systems like the strategic bomber and the intercontinental ballistic missile (ICBM), the United States can blunt some of the risks posed by aerial hypersonic weapons. Some approaches include improving the ability to detect and track these weapons and improving active and passive defenses of forward-deployed forces. Popular media often vaunts aerial hypersonic weapons as unstoppable, but they do have weaknesses that a defender might exploit. Arms control may also be part of the solution. However, the United

States will likely need to gain some advantage in offensive hypersonic weaponry to bring either Russia or China into negotiations.

Lessons from History

The arrival of aerial hypersonic weapons shares some similarities to the introduction of other long-range strike systems, such as the ICBM and the strategic bomber. Prominent Italian airpower theorist Giulio Douhet predicted in the 1930s that the strategic bomber would reduce warfare to a contest of who could level their enemy's cities more quickly and which nation's citizenry would be first to revolt against their government's war effort.[1] Stanley Baldwin echoed these sentiments in Britain's House of Commons in 1932, asserting that "[i]n the next war you will find that any town within reach of an aerodrome can be bombed within the first five minutes of war to an extent inconceivable in the last War."[2] Baldwin also said that defense against bombers was nearly futile, citing the vast airspace that fighter aircraft would have to patrol to have a reasonable chance of detecting an incoming bomber group.

By the mid-twentieth century, strategic thinkers viewed the ICBM as similarly disruptive. Strategist Herman Kahn wrote in the 1960s of the potential for ICBMs and other ever-ready nuclear weapons to make wars much easier to start, as their constant readiness would obviate the need to mobilize large armies and navies to begin a major military effort.[3]

Though these technologies changed the nature of warfare, they did not have the effect some thinkers had feared.[4] The British experience in World War II contradicted Baldwin and Douhet's visions of bomber-dominated warfare, as technologies like radar allowed the Royal Air Force to employ its fighter aircraft more efficiently than predicted.[5] During the Cold War, major powers responded to the ICBM's emergence by constructing early warning systems that exploited a ballistic missile's highly lofted trajectory to detect and track them over great distances. States created hardened and dispersed nuclear forces and arms control treaties that enshrined rough parity in strategic nuclear

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Banner Image: *A B-52H Stratofortress assigned to the 419th Flight Test Squadron takes off from Edwards Air Force Base. The aircraft conducted a captive-carry flight test of the AGM-183A Air-launched Rapid Response Weapon (ARRW) Instrumented Measurement Vehicle 2 hypersonic prototype.* Source: U.S. Air Force, Matt Williams

[1] Giulio Douhet, *The Command of the Air* (1921), 2019 ed. (Maxwell Air Force Base, Alabama: Air University Press, 2019), 7–14.

[2] Stanley Baldwin, "A Fear for the Future," (speech, House of Commons of the United Kingdom, November 10, 1932), https://missilethreat.csis.org/wp-content/uploads/2020/09/A-Fear-for-the-Future.pdf.

[3] Kahn wrote in 1965, ""Hence, one argument against nuclear war is that it may be peculiarly unstable, or volatile, because the tendency for social lethargy to brake violence is reduced nearly to the vanishing point. Preparations for large scale conventional war are painful; for nuclear war, they are not. The restraints on the outbreak of large-scale violence in nuclear war are therefore chiefly, intellectual, ethical, or doctrinal ones." Herman Kahn, On Escalation: Metaphors and Scenarios, Revised ed. (New York: Frederick A Praeger Inc., 1968), 121.

[4] Even prior to these developments, history is rife with other examples of weapon systems that are viewed as having the potential to upend the sociopolitical order. The introduction of the crossbow, for instance, gave an ordinary foot soldier with little training the capability to kill armored knights. The Catholic church viewed this clear threat to the landed nobility from the peasant class as so societally destabilizing that the Pope Urban II banned the use of crossbows in inter-Christian wars. Military utility would eventually trump piety, and crossbows became common on European battlefields by the 1200s. Later Papal bans on gunpowder weapons (which also great compress the OODA loop compared to pre-gunpowder forms of attack) went essentially ignored. See: Bernard Brodie, Fawn M. Brodie and Elisabeth Schüssler Fiorenza, *From Crossbows to H-Bombs* (Bloomington, IN: Indiana University Press, 1973).

[5] Baldwin stated in his 1932 speech, "Imagine 100 cubic miles covered with cloud and fog, and you can calculate how many aeroplanes you would have to throw into that to have much chance of catching odd aeroplanes as they fly through it. It cannot be done, and there is no expert in Europe who will say that it can."

weapons. Such adaptations limited the ICBM's usefulness as a deterrent against existential threats and its actual employability to all but the most extreme national crises.

Today, many scholars view the advent of new hypersonic missiles as potentially disruptive to the balance of military power.[6] Indeed, hypersonic glide vehicles and cruise missiles present unique challenges to the status quo military balance. But like past technological changes, countries like the United States can adapt to aerial hypersonic weapons in ways that blunt their more disruptive qualities.

Characteristics of Aerial Hypersonic Weapons

The term "hypersonic" commonly refers to speeds greater than Mach 5. Yet speed is only one characteristic that defines emerging hypersonic weapons. After all, most ballistic missiles fly at speeds well above the hypersonic threshold, and these systems have been around for many decades. The novel quality of aerial hypersonic weapons is their ability to maintain hypersonic speeds within the atmosphere. This ability allows them to use aerodynamic forces to maneuver and follow less predictable flight paths than traditional ballistic missiles. Their flight altitudes are also lower than ballistic missiles, making them harder to detect and track with ground-based radars.

There are two basic kinds of aerial hypersonic weapons: hypersonic glide vehicles (HGVs) and hypersonic cruise missiles (HCMs). HGVs and HCMs are similar in that they fly within the atmosphere and are maneuverable. Among their main differences is their propulsion. HGVs are boosted to near space by a rocket booster. After their release, they will typically dive to a lower altitude before leveling off and using inertia to glide through the atmosphere to their target. HCMs typically use a small rocket booster to accelerate the missile to speeds high enough to activate a supersonic-combustion ramjet (scramjet) engine. Therefore, unlike HGVs, HCMs are powered throughout their entire flight. HCMs also differ from HGVs in that their motors do not need to carry fuel oxidizer, allowing them to be smaller than HGVs. This characteristic makes them more attractive to air forces, as aircraft could carry larger numbers of missiles.[7]

Like past technological changes, countries like the United States can adapt to aerial hypersonic weapons in ways that blunt their more disruptive qualities.

While a key attribute of aerial hypersonic weapons is maneuverability, it is important not to overstate the agility of either HGVs or HCMs. Maneuvering at such high speeds using fins or other control surfaces produces immense amounts of atmospheric drag. Excess maneuvering at hypersonic speeds could reduce the missile's velocity and range potential.[8] For HCMs, the need to maintain a stable intake of air into the scramjet engine also limits

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[6] See: Dean Wilkening, "Hypersonic weapons and strategic stability," *Survival* Volume 6, No. 5 (October-November 2019: 129-148.

[7] Mark Lewis, "A Conversation with Dr. Mark Lewis on the Pentagon's Defense Modernization Priorities," (moderated conversation, Hudson Institute, Washington DC, June 30, 2020), https://www.hudson.org/events/1835-video-event-a-conversation-with-dr-mark-lewis-on-the-pentagon-s-defense-modernization-priorities62020.

[8] Ivan Oelrich, "Cool your jets: Some perspective on the hyping of hypersonic weapons," Bulletin of the Atomic Scientists 76, no. 1 (2020): 37–45, doi:10.1080/00963402.2019.1701283.

maneuverability.[9] As Ivan Oelrich aptly states, "[t]here will always be engineering tradeoffs so that when hypersonic weapons are described as being able to do *X, Y*, and *Z*, it is more accurate to say they can do *X* or *Y* or *Z*."[10]

Another characteristic of hypersonic flight within the atmosphere is that it is typically at these speeds when kinetic energy transforms into heat, a process called atmospheric heating. Coping with the intense heat of hypersonic flight has been a principal barrier to producing practical hypersonic weapons. Recent technological developments in materials such as ultra-high temperature ceramics (UHTCs) are among the breakthroughs that have brought about greater interest in aerial hypersonic weapons.

Emerging Capabilities

Several countries are developing aerial hypersonic weapons. China, Russia, and the United States are furthest along. China and Russia claim to have already deployed operational missiles equipped with an HGV—the DF-17 and Avangard systems, respectively. Russia may also be nearing deployment of a hypersonic cruise missile, the 3M-22 "Tsirkon." However, these development programs are highly secretive, and discerning real advancements from propaganda can be a challenge. A 2019 United Nations report stated, for example, that "[t]he secrecy surrounding these programmes also fuels exaggerated threat perceptions, leading the arms racing dynamic."[11]

The United States has several hypersonic weapon programs underway across the Army, Navy, and Air Force. The Army and the Navy are leveraging the jointly developed Common Hypersonic Glide Body for their respective Long-Range Hypersonic Weapon (LRHW) and the Conventional Prompt Strike (CPS) programs. The Air Force is pursuing the Air-Launched Rapid Response Weapon, a smaller HGV that can arm several Air Force aircraft, including the B-52 and the F-15.[12] The Air Force is also leading the pursuit of a HCM with its so-called Mayhem System Demonstrator, which leverages the work of several Department of Defense (DOD) development programs such as DARPA's Hypersonic Air-breathing Weapon Concept (HAWC).[13]

Several other countries are also pursuing hypersonic programs. Japan has begun large investments into both an HCM and an HGV program.[14] India is working with Russia to develop the Brahmos II HCM, a scramjet-powered follow-on to the supersonic Brahmos I.[15] In September 2020, India announced it had test flown an indigenously-

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[9] Lewis.

[10] Oelrich, 37.

[11] United Nations Office for Disarmament Affairs, *Hypersonic Weapons: A Challenge and Opportunity for Strategic Arms Control* (New York: United States, 2019), 16, https://www.un.org/disarmament/publications/more/hypersonic-weapons-a-challenge-and-opportunity-for-strategic-arms-control.

[12] John A. Tirpak, "Roper: The ARRW Hypersonic Missile Better Option for USAF," *Air Force Magazine*, March 2, 2020, https://www.airforcemag.com/arrw-beat-hcsw-because-its-smaller-better-for-usaf/.

[13] Valerie Insinna, "The US Air Force wants to develop a hypersonic cruise missile," Defense News, April 30, 2020, https://www.defensenews.com/industry/techwatch/2020/04/30/the-air-force-wants-to-develop-a-hypersonic-cruise-missile/; and Andrew Knoedler, "Hypersonic Air-breathing Weapon Concept (HAWC)," Defense Advanced Research Projects Agency, https://www.darpa.mil/program/hypersonic-air-breathing-weapon-concept.

[14] Mike Yeo, "Japan unveils its hypersonic weapons plans," *Defense News,* March 13, 2020, https://www.defensenews.com/industry/techwatch/2020/03/13/japan-unveils-its-hypersonic-weapons-plans/.

[15] Kelley M. Slayer, *Hypersonic Weapons: Background and Issues for Congress*, CRS Report No. R45811 (Washington, DC: CRS, updated August 2020), 16, https://fas.org/sgp/crs/weapons/R45811.pdf.

developed scramjet-powered missile, which reportedly sustained scramjet combustion for 20 seconds and achieved Mach 6.[16]

Intense resourcing by China, Russia, and the United States has allowed them to rapidly mature their hypersonic capabilities. Based on current timetables, all three militaries will probably possess some hypersonic capabilities by the mid-2020s, with the potential for faster growth after that. The cost of producing these systems may prove to be less than often imagined. For example, the DOD's Director of Defense Research and Engineering for Modernization Dr. Mark Lewis has noted that a scramjet engine's mechanics are less complex than a subsonic cruise missile's jet engine, potentially making them cheaper to manufacture.[17]

Summary of Hypersonic Weapon Systems

System	Country	Type	Status	Expected Initial Operational Capability
DF-17	China	HGV	Possibly operational	2019–2020
Lingyun-1	China	HCM	Experimental Prototype	N/A
Avangard	Russia	HGV	Operational	2019
3M-22 Tsirkon	Russia	HCM	In development	Unknown
Kinzhal[18]	Russia	Other	Operational	2019
ARRW	USA (Air Force)	HGV	In development	2021–2022
LRHW	USA (Army)	HGV	In development	2023–2024
Conventional Prompt Strike	USA (Navy)	HGV	In development	2027–2028
Mayhem System Demonstrator[19]	USA (Air Force)	HCM	In development	Unknown
Brahmos II	India / Russia	HCM	In development	2025–2028
Hypersonic Cruise Missile	Japan	HCM	In development	2024–2028
Hypervelocity Gliding Projectile	Japan	HGV	In development	2024–2028

[16] "DRDO successfully flight tests Hypersonic Technology Demonstrator Vehicle," Indian Ministry of Defence, Release 1651956, September 7, 2020, https://www.pib.gov.in/PressReleasePage.aspx?PRID=1651956.

[17] Lewis.

[18] Kinzhal is an air-launched version of the 9M723 Iskander-M ballistic missiles, which flies at hypersonic speeds mostly in the atmosphere. Although Russia characterizes it as a hypersonic weapon, it does not fit cleanly into either the HGV or HCM categories. See: Missile Defense Project, "Kinzhal," Missile Threat, CSIS, March 27, 2018, last modified June 23, 2020, https://missilethreat.csis.org/missile/kinzhal/.

[19] Theresa Hitchens, "ARRW To Mayhem To The Future Of Hypersonic Operations," *Breaking Defense*, August 31, 2020, https://breakingdefense.com/2020/08/arrw-to-mayhem-to-the-future-of-hypersonic-operations/; and Pat Host, "USAF seeks information on 'Mayhem' expendable hypersonic air-breathing demonstrator," *Janes*, August 18, 2020, https://www.janes.com/defence-news/news-detail/usaf-seeks-information-on-mayhem-expendable-hypersonic-air-breathing-demonstrator.

How Aerial Hypersonic Weapons Affect the Strategic Environment

Except for Russia's Avangard HGV, the aerial hypersonic weapons entering the scene today are mid-range with predominately theater-level applications. The chief U.S. concern with aerial hypersonic weapons, therefore, is the threat they pose to forward-based forces, and their potential to compress the time available for these forces to react to an attack. This compression is due to their speed and the relatively low altitudes at which they fly. Flying low puts a hypersonic weapon outside of ground-based sensors' field of view until the missile may be too close to take active or passive defensive measures before impact. This characteristic raises the risk that an adversary could successfully conduct a surprise attack to debilitate regional U.S. military capabilities. Strikes against command, control, and communications hubs could also undermine coordination of a U.S. military response.

This loss of warning time has a deleterious effect on the United States' approach to deterring aggression against its allies and interests. An essential part of the U.S. defense posture is forward-based forces. In addition to signaling commitment to allies and adversaries, forward U.S. forces provide a "fight tonight" capability that can prevent the enemy from achieving a *fait accompli* before reinforcements arrive. In this way, these forces contribute to deterrence by complicating an adversary's planning and raising doubts that they could accomplish their military aims quickly (if at all). Should the survivability of these forces in the initial phases of a conflict come into question, however, their potency as a deterrent could be diminished, making conflict more likely.

U.S. airbases could be particularly at risk. A study on airbase survivability found that airbases are typically the first assets an aggressor will target, given their military importance and the relative ease of destroying aircraft on the ground compared to downing them in flight.[20] A successful airbase attack, however, has required a high degree of surprise to prevent the defenders from dispersing or scrambling aircraft out of harm's way.[21] The short warning times for aerial hypersonic missiles would seem to make them particularly suited for achieving such surprise.[22]

To be sure, compressed warning times remain a problem with high-flying ballistic missiles as well. Yet the detection and tracking challenge associated with low-flying hypersonic weapons exacerbates the problem. A notional 2,000 km-ranged radar on Guam, for example, could likely begin tracking an incoming intermediate-range ballistic missile approximately 10-12 minutes before its impact. That same radar would likely start tracking an HGV no more than 3 minutes before its impact.[23]

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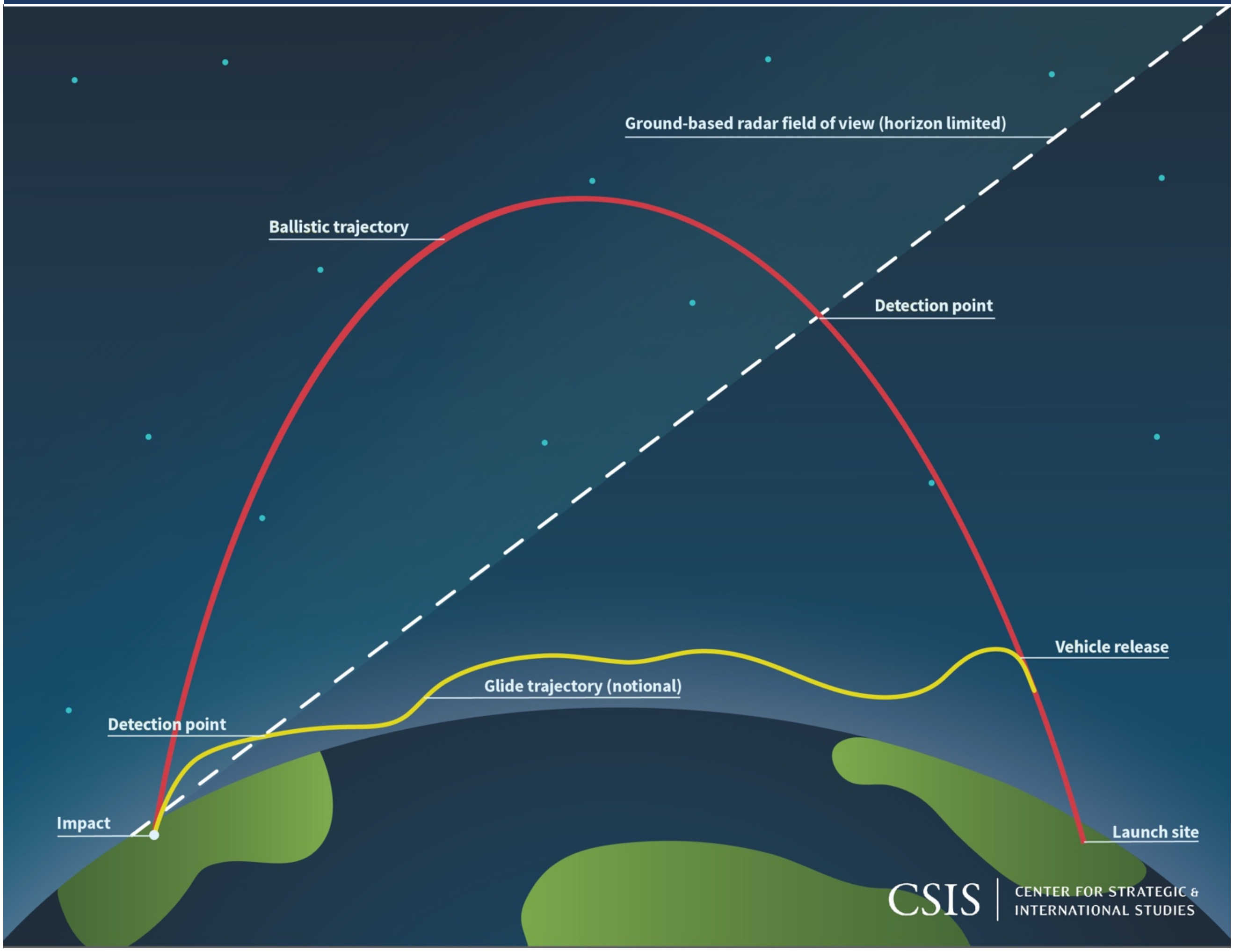
[20] Sal Sidoti, Airbase Operabiliity: *A Study in Arbase Survivability and Post-Attack Recovery, 2nd ed.* (Aerospace Centre: Royal Australian Air Force: 2001), 58-59, https://airpower.airforce.gov.au/APDC/media/PDF-Files/Fellowship%20Papers/FELL20-Airbase-Operability-A-Study-in-Airbase-Survivalability-and-Post-Attack-Recovery.pdf.

[21] Ibid.

[22] John Harvey writes in 2020, "Early warning will become increasingly challenging. As Russia and China deploy nuclear- and conventional-armed hypersonic cruise missiles and hypersonic glide vehicles, they will be able to threaten strikes with weapons that are extremely difficult to track, characterize, and intercept." John Harvey, "Modernizing the U.S. Nuclear Arsenal—The Road to 2030 and Beyond," 25, in *Fit for Purpose? The U.S. Strategic Posture in 2030 and Beyond*, e.d. Brad Roberts, Lawrence Livermore National Laboratory: Center for Global security Research (October 2020), 25, https://cgsr.llnl.gov/content/assets/docs/The-US-Strategic-Posture-in-2030-and-Beyond.pdf.

[23] Estimates based on simulations run on SmartSet, an air and missile defense simulation tool.

Figure 1: Ballistic and Glide Trajectories vs. Terrestrial Sensor



Adaptations

Just as countries adapted to past disruptive technologies, the United States needs to find ways to adjust to the hypersonic era. The first step should be to improve the United States' ability to detect and track hypersonic weapons early in their flight.

Detection, Classification, and Tracking

During the Cold War, the United States adapted to the threat of strategic bombers and ICBMs by building radar systems like the Ballistic Missile Early Warning System and the Distant Early Warning Line. Likewise, an indispensable part of adapting to this new era must be to increase the capability to detect and track aerial hypersonic weapons. Earlier detection and tracking would allow U.S. military forces considerably more time to gain situational awareness and additional time to take defensive measures. Such measures may include readying active defenses and applying passive measures such as scrambling aircraft, dispersing forces, or taking shelter. As Joseph Buontempo and Joseph Ringer suggest, threat detection and warning systems are "perhaps the most important" enablers for airbase protection.[24] Iran's ballistic missile attack on Al-Asad airbase in January 2020 is also a poignant reminder of the importance of adequate early warning in safeguarding U.S. troops.[25]

A space-based sensor architecture will be necessary to realize a hypersonic early warning capability. Given the limitations of ground-based sensors, a space-based solution is the only way to provide robust "birth to death" tracking of HGVs. While current U.S. space-based infrared detection satellites would likely detect the launch of an HGV, it is unlikely to provide any information once the missile's booster has burned out.

The United States has pursued such a capability through several programs. The Space Development Agency is developing a constellation of wide-view satellites in low Earth orbit for hypersonic detection and tracking. In parallel, the Missile Defense Agency is pursuing the Hypersonic and Ballistic Tracking Space Sensor (HBTSS) program, which in addition to tracking, will be able to provide both early warning and fire control data to U.S. missile defenses.[26]

Other solutions may be required to counter HCM threats as they emerge. Unlike HGVs, HCMs fly lower, are smaller, and present a dimmer thermal signature. As satellites may not track them reliably, HCMs may require an aerial sensor solution using aircraft, UAVs, aerostats, or dirigibles. Such an approach could mitigate the line-of-sight limitations of surface-based solutions while offering a higher sensitivity than space sensors. Nonetheless, ground-based radars can still provide crucial information on HCMs in flight, and their persistence makes them an essential part of the overall sensor mix.

Even with early detection and tracking, targeting ambiguity remains a challenge with aerial hypersonic weapons.[27] Improved tracking and classification of hypersonic weapons may still alleviate this issue to some degree. Although hypersonic weapons are maneuverable, there are limitations to their targeting footprint. A robust tracking capability for HGVS or HCMs could help narrow the list of potential targets based on the threat's initial vector. This ability to characterize a hypersonic weapon early in its flight could provide important information, such as whether it poses a threat to the U.S. homeland.

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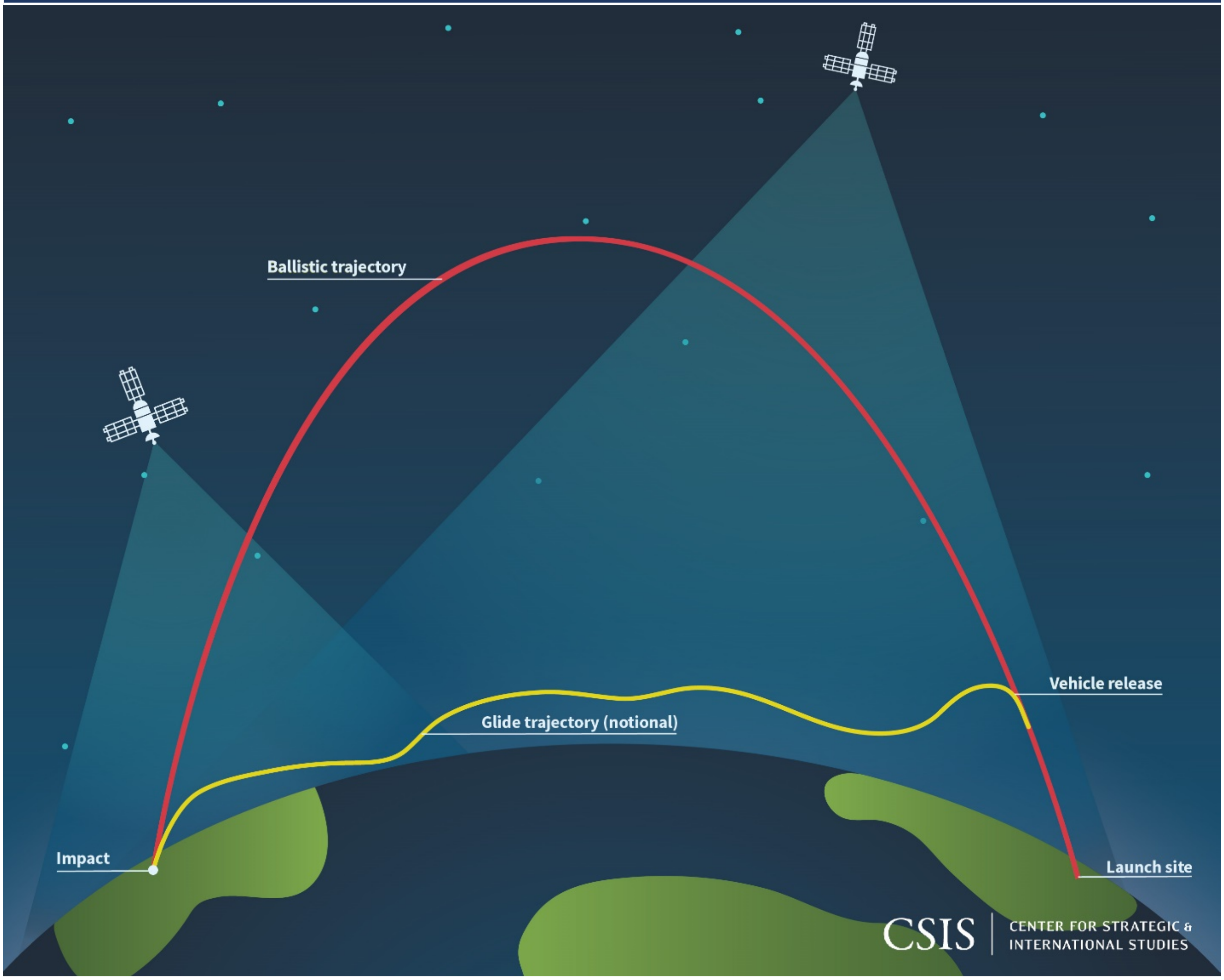
[24] Joseph T. Buontempo and Joseph E. Ringer, "Airbase Defense Falls Between the Cracks," *Joint Force Quarterly* 97, 2nd Quarter (April 2020): 118, https://ndupress.ndu.edu/Portals/68/Documents/jfq/jfq-97/jfq-97_114-120_Buontempo-Ringer.pdf.

[25] Nathan Strout, "US Space Force confirms Space Based Infrared System detected missile attack in January," *C4ISRnet*, September 15, 2020, https://www.c4isrnet.com/battlefield-tech/space/2020/09/15/space-forms-confirms-space-based-infrared-system-detected-missile-attack-in-january/.

[26] Sandra Erwin, "Missile Defense Agency selects four companies to develop space sensors," *Space News*, October 30, 2019, https://spacenews.com/missile-defense-agency-selects-four-companies-to-develop-space-sensors/.

[27] Wilkening, 131.

Figure 2: Ballistic and Glide Trajectories vs. Space-Based Sensors



Active Defenses

While still very early in development, active defenses against aerial hypersonic weapons could have a stabilizing effect. Defenses would complicate adversary attack planning, sowing doubt about its chances of achieving a rapid *fait accompli* through force. Defenses may also increase the forces necessary to execute an attack, making it easier for the United States to detect attack preparations and take preventative diplomatic or military actions. Having the means to defend sensitive assets such as command, control, and communications hubs and important surveillance assets could also reduce pressure on U.S. decisionmakers to take preemptive actions.

Defenses against hypersonic weapons will require the development of new interceptor systems. Then-Under Secretary of Defense for Research and Engineering Michael Griffin stated that the United States would likely not deploy a dedicated hypersonic defense system until at least the mid-2020s.[28] The first of such systems will probably

[28] Slayer, 8.

be point defenses; batteries able to defend a small area against a hypersonic missile in its terminal phase of flight. A longer-range midcourse intercept system could then follow on to provide a layered defense.[29]

There are two efforts underway pursuing counter hypersonic development. One is MDA's Hypersonic Defense Regional Glide Phase Weapons System (RGPWS), a research and development program focused on maturing the technologies necessary for a hypersonic defense system.[30] A second is DARPA's Glide Breaker program, intending to "develop and demonstrate technologies to enable defense against hypersonic systems."[31]

There may be other approaches to countering hypersonic weapons in addition to the kinetic, "hit-to-kill" solutions that have dominated U.S. ballistic missile defenses. Aerial hypersonic weapons possess weaknesses that a defender might exploit. As previously discussed, a hypersonic weapon trades off between speed, altitude, and maneuverability. A hypersonic glider has only a finite amount of energy available to reach its target. As such, even forcing an HGV to make evasive maneuvers could expend enough of its energy that it can no longer complete its mission. Oelrich points out that "[h]igh-acceleration jinking, either to avoid interceptors or home in on a target, will come at a very steep price in speed."[32] When it comes to HCMs, the sensitivity of the scramjet engine to pitch and yaw may furthermore prove a weakness that a defense system could take advantage of.[33]

Of course, the foundation for any active defense against counter-hypersonic systems rests on having adequate detection and tracking capabilities, as described above.

Passive Defense and Distribution

Another important line of effort in countering hypersonic weapons is to increase the resilience of forward-based forces through passive measures like hardening, dispersion, and deception. Making in-theater forces more challenging to find, target, and destroy can further complicate an adversary's attack planning and confidence of success, thus enhancing deterrence. The DOD highlighted the need for such approaches in the 2018 National Defense Strategy, which prioritized "[t]ransitioning from large, centralized, unhardened infrastructure to smaller, dispersed, resilient, adaptive basing that include active and passive defenses[.]"[34]

U.S. airbases may be in particular need of more resiliency and dispersion. The United States currently amasses a considerable amount of firepower at just a handful of bases worldwide, making them tempting targets for massed fires. A 2019 report noted that "[i]ncreasing the number of the combat air force's operating locations would. . .help decrease China's or Russia's ability to concentrate their missile attacks on a small number of airfields."[35] Other

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[29] Jen Judson, "MDA pauses defensive hypersonic missile design to refocus plan," *Defense News*, August 4, 2020, https://www.defensenews.com/digital-show-dailies/smd/2020/08/04/mda-pauses-defensive-hypersonic-missile-design-effort-to-refocus-plan/.

[30] "Draft Request for Prototype Proposal: Hypersonic Defense Regional Glide Phase Weapon System," Missile Defense Agency, January 30, 2020, 8, https://beta.sam.gov/opp/e01d8ad5d7134a97a0ff0c5cac0021da/view.

[31], "Glide Breaker," Defense Advanced Research Projects Agency, https://www.darpa.mil/program/glide-breaker.

[32] Oelrich, 38.

[33] Richard Stone, "'National pride is at stake.' Russia, China, United States race to build hypersonic weapons," *Science Magazine,* January 8, 2020, https://www.sciencemag.org/news/2020/01/national-pride-stake-russia-china-united-states-race-build-hypersonic-weapons.

[34] James Mattis, "Summary of the 2018 National Defense Strategy of the United States of America," Department of Defense, 2018, 6.

[35] Mark Gunzinger, Carl Rehberg, and Lukas Autenried, *Five Priorities for the Air Force's Future Combat Air Force* (Washington, DC: CSBA, 2020), 37, https://csbaonline.org/research/publications/five-priorities-for-the-air-forces-future-combat-air-force.

mitigating efforts could include greater aircraft dispersion within a base or hardening hangers to withstand missile hits. The military might explore decoys, dummies, or other means of deception and redirection. [36]

Congress has shown interest in supporting better protection for overseas military installations. Both the Senate versions of the FY 2021 National Defense Authorization Act (NDAA) contain funding for a *Pacific Deterrence Initiative* (PDI)" that seeks to, among other goals, "increase lethality of the Joint Force in the Indo-Pacific, including by improving active and passive defense against theater cruise, ballistic, hypersonic missiles for bases, operating locations, and other critical infrastructure."[37] The Senate version would authorize $1.4 billion for PDI-related measures in FY 2021 and directs the secretary of defense to form a spending plan for up to $5.5 billion in FY 2022.[38] The House version of the FY 2021 NDAA contains a like-minded Pacific Reassurance Initiative, which directs the Pentagon to assess the kinetic vulnerability of U.S. positions in the Asia-Pacific and explore various mitigation options including base "hardening and resiliency measures."[39]

Arms Control

Arms control agreements have remained an essential tool for reducing the risks of nuclear war. Treaties like START and New START have maintained strategic nuclear parity, making it practically impossible for one side to execute a disarming first strike. Moreover, nuclear arms control treaties have added considerable transparency to the parties' capabilities, permitting a more accurate assessment of what each country can and cannot do with its strategic nuclear forces. Naturally, many scholars have also looked to arms control as a possible way to mitigate the risks of hypersonic weapons. There has been some discussion of what an agreement on hypersonic weapons might look like or what it might seek to accomplish. Ideas have ranged from an international ban on hypersonic testing to expanding the New START regime with a follow-on treaty on HGVs.[40]

There are many barriers to concluding an arms control agreement that encompasses new hypersonic weapons. First, such a treaty would need to include China, a country with no history of strategic arms limitations and which has displayed little interest in engaging in arms control talks.[41] Russia, meanwhile, may insist on tying hypersonic weapon limitations to constraints on U.S. missile defenses, which the United States has firmly stated it would reject.[42] Furthermore, the focus of New Start is on intercontinental-range missiles with nuclear warheads. The bulk of aerial hypersonic missiles emerging are short-intermediate ranged systems equipped with conventional warheads. As such, a New Start follow on may not be the best arms control vehicle for tackling aerial hypersonic

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[36] Thomas Karako and Wes Rumbaugh, Distributed Defense: New Operational Concepts for Integrated Air and Missile Defense (Washington, DC: CSIS, 2016), 37–41, http://missilethreat.csis.org/wp-content/uploads/2018/01/Distributed-Defense.pdf.

[37] United States Senate Armed Services Committee, *Fiscal Year 2021 National Defense Authorization Act* (Summary) (Washington, DC: 2020), 5–6, https://www.armed-services.senate.gov/imo/media/doc/FY%2021%20NDAA%20Summary.pdf.

[38] Ibid.

[39] U.S. Congress, House, *William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021* , HR 6395, 116th Cong., 2nd sess., August 4, 2020, https://www.congress.gov/116/bills/hr6395/BILLS-116hr6395pcs.pdf.

[40] For a good summary of several possible arms control approaches to hypersonic weapons, see: United Nations Office for Disarmament Affairs, *Hypersonic Weapons: A Challenge and Opportunity for Strategic Arms Control*, 30–35.

[41] Nicole Gaouette and Jennifer Hansler, "China dismisses US outreach on arms control talks saying it has 'no interest'," CNN, July 9, 2020, https://www.cnn.com/2020/07/09/politics/state-china-us-arms-control/index.html.

[42] Both the Obama and Trump administration's missile defense policies expressly said the United States would not accept any negotiated limitations on its missile defense activities. See Office of the Secretary of Defense, Ballistic Missile Defense Review (Washington, DC: Department of Defense, 2010), VI; Office of the Secretary of Defense, Missile Defense Review (Washington, DC: Department of Defense, 2019), VII, https://media.defense.gov/2019/Jan/17/2002080666/-1/-1/1/2019 -MISSILE-DEFENSE-REVIEW.PDF.

missiles. Rather, a future agreement limiting hypersonic weapons may more closely resemble the Intermediate 1987 Intermediate Range Nuclear Forces Treaty.

Perhaps the most critical barrier to achieving an arms control solution, however, is motivation. Russia and China see a strategic benefit to hypersonic weapons and are likely to resist limitations in the near term. The United States should, therefore, seek to shape the strategic environment over the long term to bring both parties to the table. Both diplomatic and military approaches will likely be necessary. As Frank Rose notes, "[e]ngaging China on arms control and strategic stability issues will require a mix of deterrence and dialogue."[43] It may take the United States gaining some advantage in offensive hypersonic weapons to pique Chinese or Russian interest in negotiated forms of control or reduction. The history of arms control with the Soviet Union suggests that Moscow was most interested in arms control when it felt like it was falling behind.[44]

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Perhaps the most feasible near-term approach would be establishing data exchanges, which could include numbers of hypersonic weapons, their types, ranges, payload types (nuclear vs. conventional), and increasing the transparency on weapons testing. James Acton wrote in 2013 that such data exchanges "could enhance each side's confidence in its estimates of the other side's forces and increase predictability." More recently, some scholars have suggested that China may be more open to transparency with its strategic forces "due to growing confidence in the survivability of its nuclear forces and because secrets are increasingly hard to keep in a world of high-resolution commercial satellites and widespread sharing of information on the internet."[45]

Arms control approaches hold promise, but the road ahead is murky. Therefore, it would be risky to bet too much on a negotiated solution to mitigate the dangers of hypersonic weapons. Ultimately, it may take time for the current political barriers to make way for engagement.

Conclusion

Hypersonic weapons pose a new but surmountable challenge to U.S. defenses and international strategic stability. However, the process of acclimating to these new systems is not inevitable and will require resources, ingenuity, and prioritization. It is also crucial that the United States not become myopic to this new threat. Aerial hypersonic weapons do not exist in a vacuum, and adversaries will employ them in concert with other strike systems, including

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[43] Frank A. Rose, "Bringing China into the fold on arms control and strategic stability issues," Brookings Institution, September 25, 2019, https://www.brookings.edu/blog/order-from-chaos/2019/09/25/bringing-china-into-the-fold-on-arms-control-and-strategic-stability-issues/.

[44] A 1983 CIA assessment, for example, concluded that "On the basis of the Soviet approach to arms control negotiations during the past 20 years, our analysis of current Soviet military programs, and our understanding of Soviet strategic an dpolit8cal objectives, we expect the USSR to continue to seek strategic advantages through the arms control process and to weight this more heavily than any concerns about the arms race, its costs, or its contribution to instability." "The Soviet Approach to Arms Control: Implications for START and INF," CIA Director of Central Intelligence, NIE 11-16-83, https://www.cia.gov/library/readingroom/docs/DOC_0000284023.pdf.

[45] Frank G. Klotz, John Lauder, and William Courtney, "Negotiating with Great Powers on Nuclear Arms," The RAND Blog, August 3, 2020, https://www.rand.org/blog/2020/08/negotiating-with-great-powers-on-nuclear-arms.html.

ballistic missiles, subsonic cruise missiles, drones, and artillery. The United States needs to address these threats as comprehensively as possible.

There remain many unknowns about how the hypersonic era will evolve. The United States needs to maintain the flexibility to continue adapting as circumstances warrant. Should active defenses against hypersonic weapons prove untenable, the United States may need to reconsider its overall global force posture, rebalancing from forward-based forces toward more out-of-region standoff capabilities. Arms control solutions may seem untenable in today's strategic environment. Yet there may come a time when the parties are ready to engage, and the United States must prepare to capitalize on moments of diplomatic opportunity. Despite the uncertainties, states adapted to disruptive technologies in the past and can do so again.

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