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March 13, 2020

# Defense Primer: Hypersonic Boost-Glide Weapons

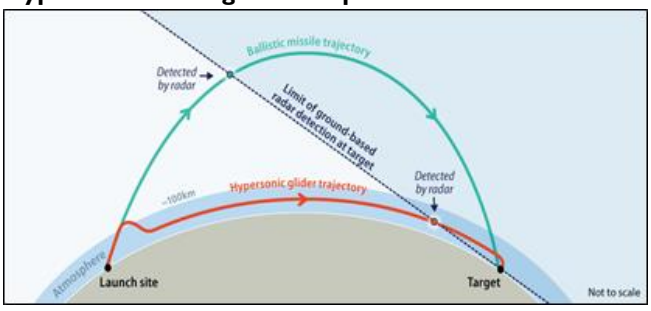
The U.S. Department of Defense is pursuing two types of hypersonic weapons technologies: boost-glide systems that place a maneuverable glide vehicle atop a ballistic missile or rocket booster, and cruise missiles that would use high-speed, air-breathing engines known as scramjets to travel to hypersonic speeds. This In Focus addresses only the first of these technologies.

The Pentagon's FY2021 budget request for hypersonic-related research is $3.2 billion—up from $2.6 billion in the FY2020 request—including $206.8 million for hypersonic defense programs. This increased funding and statements from Pentagon officials demonstrate growing support for weapons that could attack priority targets promptly and with improved accuracy without facing defeat by an adversary's air or missile defense systems. Pentagon officials have also expressed concerns about advances in hypersonic weapons technologies in Russia and China, and on the potential threats to U.S. forces, allies, and territory.

## Characteristics of Hypersonic Glide Vehicles

Hypersonic glide vehicles (HGVs), like all weapons delivered by medium- and longer-range rocket boosters, can travel at speeds of at least Mach 5, or about 1 mile per second. The key difference between missiles armed with HGVs and missiles armed with ballistic reentry vehicles (i.e., those that travel on a ballistic trajectory throughout their flight) is not their speed, but their ability to maneuver and change course after they are released from their rocket boosters. In addition, although it is not necessary, many concepts for the delivery of HGVs presume that the boosters will launch along a flatter, or depressed, trajectory than standard ballistic missiles, and will release their gliders at a lower altitude of flight (see **Figure 1**).

**Figure 1.Flight Trajectory of Ballistic Missiles vs. Hypersonic Boost-glide Weapons**




**Source:** The Economist.

Taken together, the HGVs' novel trajectory and maneuverability in flight would complicate a U.S. effort to detect, track, and defend against an attack. The United States would likely detect the booster's launch, as it would for the launch of any ballistic missile, but it would not be able to predict the HGV's flight path. In addition, although an HGV launched by a rocket booster would reach its target far more quickly than a warhead delivered by an aircraft or subsonic cruise missile (in minutes instead of hours), it would not travel faster than a ballistic reentry vehicle. However, it would be more difficult to predict the intended target and to direct missile defense interceptors toward the attacking HGV.

## Hypersonic Boost-Glide Programs

### United States

When the United States began to assess the military utility of hypersonic boost-glide weapons in the early 2000s, it sought to develop longer-range systems that could reach deep into an adversary's territory to attack defended, hardened, and time-urgent targets. (For an overview of the history of U.S. programs, see CRS Report R41464, *Conventional Prompt Global Strike and Long-Range Ballistic Missiles: Background and Issues*, by Amy F. Woolf.) More recently, the Pentagon has increased funding and accelerated development programs for shorter and intermediate-range boost-glide systems that could conduct prompt attacks against heavily defended targets in regional conflicts. The Department of Defense (DOD) is developing hypersonic weapons under the Navy's Conventional Prompt Strike program, as well as through several Air Force, Army, and DARPA programs. (Details on these programs can be found in CRS Report R45811, *Hypersonic Weapons: Background and Issues for Congress*, by Kelley M. Sayler.)

Unlike Russia and China, the United States is not developing HGVs for use with nuclear warheads. As a result, U.S. gliders may require greater accuracy and will be more technically challenging to develop than nuclear-armed Chinese and Russian systems.

### Russia

Russia's HGV, known as Avangard, is equipped with a nuclear warhead and deployed on SS-19 long-range land-based ballistic missiles. While SS-19 missiles can carry six nuclear warheads on a ballistic trajectory, reports indicate that they will deploy with only one Avangard HGV. Avangard reportedly features onboard countermeasures and will be able to maneuver in flight so that it can evade U.S. ballistic missile defenses. Russia conducted successful tests of Avangard 2016 and 2018. On December 27, 2019, the Russian military announced that it had activated two SS-19 missiles equipped with Avangard.

Russia views the Avangard system as a part of its nuclear retaliatory capability, ensuring that Russian missiles could penetrate U.S. ballistic missile defenses. According to the Pentagon's 2019 Missile Defense Review, the United States relies on nuclear deterrence, not ballistic missile defenses, to counter Russia's long-range missile forces. Nevertheless, in March 2018, President Putin stated that Russia had pursued HGV technologies in response to the U.S. 2002 withdrawal from the 1972 Anti-ballistic Missile Treaty. Some U.S. analysts, however, have noted that the Russia could use the Avangard as part of a first strike, even in the absence of U.S. ballistic missile defenses, to attack critical targets quickly. Others have assessed that Russia is likely to deploy Avangard in small numbers, so it will add little to Russia's existing nuclear force structure.

### China

China has developed an HGV known as the DF-ZF (previously referred to as the WU-14) and has tested it at least nine times since 2014. U.S. defense officials have stated that the HGV may be capable of performing "extreme maneuvers" during flight, which would allow it to evade U.S. ballistic missile defenses. Unclassified reports indicate this glider would likely be equipped with conventional warheads, and when mated with the DF-17 booster, could travel to ranges of 1,800-2,500 kilometers.

China is also developing the DF-41 long-range intercontinental ballistic missile, which, according to a 2014 report by a U.S. Congressional Commission, could carry a nuclear hypersonic glide vehicle. Gen. Terrence O'Shaughnessy, the commander of U.S. Northern Command, seemed to confirm this assessment in February 2020, when he testified that "China is testing a [nuclear-armed] intercontinental-range hypersonic glide vehicle … which is designed to fly at high speeds and low altitudes, complicating our ability to provide precise warning."

Some contend that China has prioritized HGV development to counter "specific security threats from increasingly sophisticated U.S. military technology." This includes both U.S. hypersonic weapons that could threaten strikes against China's nuclear arsenal and supporting infrastructure, and U.S. missile defense deployments that could then limit China's ability to conduct a retaliatory strike against the United States. In this framework, nuclear-armed HGVs on long-range missiles would ensure that China had the ability to retaliate after a U.S. attack, even if the United States were to expand its ballistic missile defense capabilities. HGVs on medium-range missiles would aid China's efforts to threaten U.S. assets in the Indo-Pacific region, particularly when faced with growing U.S. regional missile defense capabilities.

## Arms Race Dynamics?

Many analysts have characterized the ongoing U.S., Russian, and Chinese development of HGVs and boost-glide weapons as an arms race because each nation seems to be competing to be the first to deploy these systems. Some argue that the United States is falling behind in this contest because Russia and China have both displayed operational systems. Others argue that the United States is leading, and may be escalating the race because it has accelerated its programs and expanded them to include short-, medium-, and long-range systems.

When asked about this dynamic in February 2020, Admiral Charles Richard, the commander of USSTRATCOM, noted that there "is a competition, just like any other military competition." But he did not characterize it as an arms race. He noted that the United States was developing technologies needed to meet U.S. national objectives, and he noted that he expected the United States to be successful in meeting its security goals. Others have noted that the same is true for Russia and China; each is developing HGVs to meet their own security interests, not to counter or match the U.S. development of HGVs. Specifically, both seem to be responding to concerns about U.S. ballistic missile defense programs.

## Game-Changing Technology?

Some analysts have asserted that the speed, accuracy, and maneuverability of hypersonic boost-glide weapons will fundamentally change the character of warfare. The acting Secretary of the Navy, Thomas Modly, made this case in January 2020 when he noted that these technologies "have already changed the nature of the battlespace" and that they "can destabilize the global security environment and pose an existential threat to our nation." Others question this assessment. They note that boost-glide systems can reach their targets more quickly than other maneuverable systems, like aircraft and subsonic cruise missiles. But adversaries armed with ballistic missiles have long been able to attack U.S. forces, allies, and territory, even without maneuvering warheads. Consequently, they argue that there is nothing new about the threat from nuclear-armed HGVs, when compared with other nuclear-armed missiles, and nothing existential about a threat from conventionally armed HGVs.

## Crisis Instability?

Boost-glide systems could accelerate the pace of warfare and create incentives to strike first in a crisis. If the United States and potential adversaries develop these systems to strike promptly against high-value targets protected by missile defenses, each side may believe it has to strike first, and strike fast, to achieve its objectives. This dynamic—often referred to as crisis instability—could provoke the start of a conflict even if neither party to the crisis initially planned to strike first.

DOD is seeking to address the potential threats posed by hypersonic boost-glide weapons with programs developing defensive systems to track and engage them. Experts disagree on the cost and technological feasibility of this approach. Policymakers may also consider mechanisms to ban or limit the deployment of these weapons to avoid the crisis instabilities created by their short time of flight. On the other hand, nations might be unwilling to agree to limit these weapons without corresponding limits on missile and air defenses.

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