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# PRC Research on AI-Enabled "Intercept Avoid" Technologies For Hypersonic Missiles

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The People's Liberation Army (PLA) Dongfeng-17 (DF-17) and Dongfeng-27 (DF-27) Hypersonic Glide Vehicles (HGVs) can maneuver in flight to amplify threat potential, yet questions remain about how maneuvers are achieved and the extent to which they can adjust to avoid defensive interceptors. Much of the maneuvering of an HGV projectile is pre-programmed prior to flight using advanced computer algorithms, yet research by Chinese scientists at Nanjing University of Aeronautics and Astronautics (NUAA) proposes leveraging advanced AI-enabled neural networks to enable "intercept avoid," meaning the HGV could elude interception and continue successfully to its target. This research explores methods for recognizing, analyzing, and approximating the flight path of an HGV interceptor by "learning" and adapting flight patterns during flight. Accordingly, the research suggests that the People's Republic of China (PRC) appears to be seeking to further improve or adapt HGV maneuverability so that weapons such as the DF-17 and DF-27 can not only evade radar but also elude defensive interceptors.

## Artificial Intelligence Learns HGV Interceptor Flight Path

The PLA has likely been exploring AI-enabled technologies to counter the Department of War's nascent Golden Dome effort by engineering HGV guidance systems capable of evading defensive intercepts. While these PRC research efforts seem to have preceded the arrival of Golden Dome, they appear to be the kind of technological exploration that could be used to elude Golden Dome defenses and enable DF-17 or longer-range DF-27 HGVs to be more penetrating.

A 2022 academic research paper by researchers from the NUAA titled "Anti-Interception Guidance for Hypersonic Glide Vehicle: A Deep Reinforcement Learning Approach" proposes an AI-enabled method of evading adversary radars to yet another level of operational utility by enabling HGVs to develop "anti-interception guidance" and evade interceptors and countermeasures as well as defensive radar systems.[1] The intent of the NUAA research appears to be countering or staying ahead of U.S. technological efforts to intercept PRC hypersonic weapons, such as the DF-17, by developing what Chinese researchers refer to as HGV "anti-interception" guidance.[2] According to the article, "an intelligent network trained by deep reinforcement learning (DRL) can quickly compute a command for anti-interception guidance that matches the high dynamic characteristics of the HGV."

Chinese government-backed newspapers such as the *Global Times* have also recently published articles related to the growing capabilities of the PLA's hypersonic arsenal, at times making specific references to the DF-17's "stronger defense penetrating capability." The penetrating enhancements to the DF-17 cited in a 2025 *Global Times* article could be a general reference to the kinds of neural networks, AI-enabled guidance technology, and "anti-intercept" capability proposed in the 2022 research from NUAA. A September 3, 2025, article cites a number of performance enhancements woven into modern variants of the DF-17, to include longer "maneuvering distance," "range," and "stronger defense penetrating capability."[3] According to the article:

> At the 2019 military parade during the celebrations marking the 70th anniversary of the founding of the People's Republic of China in Beijing, the DF-17 missile made its debut. This type of missile is completely independently developed by China and can carry out precise strikes on multiple targets in all weather, multiple directions, and multiple angles. It has the characteristics of shorter launch time, longer maneuvering distance, longer effective range, greater strike power, and stronger defense penetrating capability. It is a cutting-edge weapon in the new generation of medium to short-range strike forces.[4]

**Intercept Avoid: Need for Skepticism**

While there does appear to be a linear, evidence-based equation between the research from NUAA and the PRC claim that its hypersonic glide vehicles have been improved to become more "penetrating," it seems unclear just how much this apparent parallel has translated into successful PLA action to integrate AI-enabled "intercept avoid" into its DF-17 and DF-27 HGVs. The potential integration or application of the science to operational weapons systems seems less clear, and certainly something likely to encounter developmental challenges and impediments. Also, as more complex algorithmic systems, "neural networks" can increase AI-related challenges and reliability problems far more difficult than those associated with less advanced applications of AI. These questions cast a shadow of doubt upon the prospect that the NUAA research has been actualized or fully evolved into an operational weapon capable of threatening advanced hypersonic defenses. Furthermore, it is feasible that the PRC's state-owned *Global Times* could "exaggerate" or "hypothesize" to inflate the potential effectiveness of its hypersonic weapons.

**Defending Hypersonics**

The approximate range, speed, maneuverability, and lethality of the DF-17 hypersonic boost-glide weapon have been discussed for many years in the Pentagon's annual China report and various think tank assessments, yet beneath a veneer of highly publicized testing and technological development, critical performance questions remain. The 2025 *Military and Security Developments Regarding the People's Republic of China* states that the DF-17 can travel as far as 2,000km and that the DF-27 can strike targets at ranges up to 8,000km.[5]

While there is little publicly available information related to the technology of guidance systems and in-flight maneuverability related to hypersonic glide vehicles, they are known for traveling a much less discernable flight path, as opposed to the recognizable parabola-like trajectory of a ballistic missile. Once the origin of a ballistic missile is recognized, its flight path and landing location can be quickly ascertained to a large degree, yet hypersonic glide vehicles of comparable ranges are known to maneuver and even skip along the boundary of the Earth's atmosphere. The pure speed of hypersonic flight makes it seemingly impossible for ground, sea, or air-based radar to establish a continuous target track, as HGVs travel far too quickly from one radar aperture or field of view to another. This is likely a key reason why so many industry weapons developers say emerging hypersonic weapons defenses or interceptor technologies, such as Hypersonic Ballistic Tracking Space Sensor (HBTSS) and Glide Phase Interceptor (GPI), increasingly rely upon high-throughput, lower-altitude medium Earth orbit and low Earth orbit satellites. These satellites are in lower orbit and in closer proximity to the earth and one another than traditional early warning satellites in geosynchronous orbit, so they are in a better position to establish a target track of an HGV as it transits from one field of regard to another. The Pentagon and its industry partners have for years been working on defenses against hypersonic weapons, and weapons developers are now leveraging the best available and most promising defenses against hypersonic weapons attacks; specifically, the Pentagon's Golden Dome project is, among other things, being developed to stop hypersonic attacks.

**Strategic intent**

In recent years, senior U.S. weapons developers have publicly expressed concern that the Pentagon may be third in the global competition to deploy hypersonic weapons, behind Russia and China. One primary concern relates to a potential PLA ability to exploit what could be a short-term window of hypersonic weapons superiority to create a denial zone or a specific attack perimeter, putting potential intruders at risk. Such tactics could be employed to support an invasion of Taiwan in an effort to secure what Congress' 2023 policy bill refers to as a "fait accompli."[6] The concept here would simply be to annex Taiwan quickly using highly lethal, difficult-to-defend hypersonic weapons to prevent any U.S. and allied forces from successfully intervening to defend Taiwan.

The PRC intent, as regularly described in the Pentagon reports, would be to occupy Taiwan quickly and simply make it too costly for any U.S.-allied force to extricate an entrenched PLA force.[7] Hypersonic weapons and the so-called anti-access, area-denial (A2/AD) operational environment they would seek to create could prove pivotal to an effort of this kind. According to the Pentagon's 2024 China report, "The DF-17 passed several tests and is deployed operationally. In 2020, a PRC-based military expert described the primary purpose of the DF-17 as striking foreign military bases and fleets in the Western Pacific. The People's Liberation Army Rocket Force continues to expand its DF-17 inventory, and this weapon's HGV payload is designed to evade adversary radars and BMDs."[8]

Most recently, it appears that the PLA has advanced its HGV technology beyond the DF-17, with the arrival of longer-range HGVs such as the DF-27, capable of traveling up to 4,000 miles to threaten the U.S. homeland. There were several publicly unveiled hypersonic weapons at the PRC's September 3, 2025, V-Day parade. These new weapons may or may not be engineered with AI-enabled penetrating or intercept avoid technologies. The parade showcased at least four hypersonic anti-ship missiles engineered to destroy rival ships in the Pacific or, at very least, further challenge potential adversary warships and weapons. The weapons, referred to by PLA and government-backed newspapers as the YJ-15, YJ-19, YJ-17, and YJ-20, can be air-, ground, sea, and submarine-launched.[9]

Therefore, the next step for the PLA, which the research from NUAA seems to explore, would be to harden or defend the guidance systems and networking supporting its growing arsenal of HGVs from U.S. interceptor defenses. The application of this research would be to circumvent U.S. hypersonic defensive systems such as GPI and HBTSS.

Research indicates that the PLA is exploring AI-enabled systems using DRL to harden HGVs against defensive interceptors to better ensure precision targeting, in-flight course adjustment, and the ability to evade countermeasures. Typically, an AI system is thought to only be as effective as its database, meaning it might encounter accuracy and predictability challenges when it comes upon data that is not “tagged” or already established in its data library.

However, increasingly, advanced algorithms can make more subjective determinations, enabling them to solve problems, answer questions, or discern nuances in meaning by analyzing a host of variables or indicators in relation to one another. An advanced AI system, for example, can determine the meaning of “ball” dance from foot “ball” in a sentence by analyzing the surrounding words and the context. These kinds of determinations form the conceptual foundation for what computer scientists and AI-focused technologists call “neural networks.” According to the NUAA research paper:

> In recent years, deep neural networks (DNNs) have demonstrated the ability to approximate an arbitrary function and have unparalleled advantages in the feature extraction of high-dimensional data…While many machine learning models rely on labeled datasets, reinforcement learning, including DRL, generates its own training data through interaction with its environment DRL is an AI technique that combines reinforcement learning (RL) with deep neural networks to enable agents to learn complex decision-making from raw, high-dimensional data.[10]

While somewhat nascent in 2022, the concept proposed in the NUAA research may have evolved considerably in recent years. The idea proposed in the research is to leverage AI-enabled deep neural networks to learn flight path trajectories of interceptors, the signals their seekers and sensors emit by discerning patterns, and guidance specifics determined or programmed prior to flight. A DRL approach leverages advanced algorithms to approximate specific maneuvers, detection methods, and flight path trajectories enabling the HGV to adapt to interceptor threats and adjust its pre-programmed flight path maneuvers.

The NUAA research paper states, “Anti-interception guidance can enhance an HGV compared to multiple interceptors. In general, anti-interception guidance for aircraft can be divided into procedural guidance, fly-around guidance, and active evading guidance. However, these guidance methods cannot be applied to a HGV’s unknown real-time process due to limited intelligence information or onboard computing capabilities. In this paper, an anti-interception guidance approach based on DRL is proposed.”[11]

Deep neural networks leverage advanced algorithms to recognize patterns, identify, and perform analytics on complex data, building an "increasingly abstract representation of data." According to the research paper,

> AI-enabled deep neural networks are complex AI systems, a subset of machine learning, that mimic the human brain's structure with multiple layers of interconnected artificial neurons (nodes) to learn intricate patterns from data. They process information through these layers, using a process called deep learning to build increasingly abstract representations of data, enabling them to perform sophisticated tasks like image recognition, natural language processing, and decision-making.[12]

**Growing PLA Hypersonic Arsenal**

The *Global Times* essay seems to indicate that the PLA is not only expanding the volume of its hypersonic arsenal but also increasing its capability and versatility. The essay asserts something which has long been speculated—that the DF-26D missile "may adopt some hypersonic configuration designs like the DF-17."[13] The DF-17 is officially defined as a hypersonic ballistic missile, which indicates that the DF-26D missile may adopt some hypersonic configuration designs.

The potential for additional PLA hypersonic weapons capabilities also expands beyond the road-mobile, ground-launched DF-17 to include air-launched hypersonic weapons such as the H-6K-integrated YJ-21. The *Global Times* reports: "The H-6K bomber is capable of carrying a wide variety of munitions including the KD-20 land attack missile, the YJ-12 supersonic anti-ship missile and the YJ-21 hypersonic missile."[14]

The YJ-12 is a supersonic cruise missile, as is the KD-20, yet their presence on the H-6K may indicate the presence of new kinds of fire-control and weapons guidance technologies intended to improve the strike range and accuracy of the bomber's stand-off threat to land targets in Taiwan. The most significant part of this June 19, 2023, report in the *Global Times*, however, is that it claims the H6K is now armed with a YJ-21 hypersonic missile. The YJ-21 air-launched hypersonic missile can reportedly reach speeds of at least Mach 6, if not Mach 10, according to news reports.[15] Being armed with or capable of carrying the missile does not necessarily mean that H6K night patrols over Taiwan are now carrying hypersonic missiles, yet the existence of an air-launched variant is significant. If true, it is possible that "intercept-avoid" technology is also being integrated into the PLA's most recent hypersonic weapons, such as the YJ-21 and other new missiles displayed at the September 3 parade.

The existence of an air-launched YJ-21 hypersonic missile on an H-6K was briefly mentioned in the 2023 *Global Times* essay, yet a PLA surface-launched Navy YJ-21 variant has been undergoing testing for several years. *Military Watch* magazine and *Naval News* both cite the existence of the YJ-21, yet only in terms of a surface-ship-launched application.[16] Both reports cite a PLA Navy video showing the test-firing of the YJ-21 hypersonic missile from its emerging, quasi-stealthy Type 055 Destroyers. However, neither report mentions an "air-launched" YJ-21 hypersonic missile variant, so the H6K-launched variant cited in the Chinese paper appears to be something China has officially acknowledged only recently. The existence of an air-launched YJ-21 is cited as a possibility in a *C4ISRNET* media report from the 2022 Zhuhai

Air Show, and the weapon was confirmed at Air Show China in 2024, according to the Pentagon's annual China report.[17] It therefore makes sense that the air-launched YJ-21 would be on display at the September 3, 2025, PRC parade. While the 2022 *Naval News* essay clearly points out that much remains unknown about the YJ-21, the publication quotes *Naval News* analyst H. I. Sutton as saying that the YJ-21 appears to be based on the CM-401 design. Sutton says the CM-401 is similar to the Russian Iskander, yet with a smaller diameter.[18]

The existence of an air-launched YJ-21 variant raises questions about its level of maturity, testing, and production. The range and targeting guidance technology it uses would also be of critical importance. Very little may be known or immediately discernable regarding the technological sophistication, guidance or penetrating ability of the air-launched variant, yet it seems conceivable that it could incorporate an intercept avoid penetrating capability similar to the land-launched variants. However, an apparent parallel between PRC newspaper comments about more "penetrating" HGVs and the HGV "intercept avoid" cited in the NUAA research does not verify that such advances have been successfully applied to the PLA's arsenal.

**AI Reliability**

Despite the evidence-based prospect of PLA advances in AI-empowered "intercept-avoidance" technology for HGVs, it seems prudent to view such potential breakthroughs with a measure of skepticism. This is largely due to the known reliability challenges associated with AI applications. An AI-capable system is typically only as effective as its database, meaning it can encounter reliability and data identification problems when encountering something not previously "learned," "tagged," or integrated into a database.

Increasingly, advanced AI systems are learning to discern meaning and make identifications more subjective in nature. This is accomplished by correctly using a more holistic method of examining context and a range of variables in relation to one another. This is how AI can approximate and make identifications of data not previously learned, a concept articulated in NUAA's research on neural networks. For example, industry innovators are developing integrated, holistic algorithmic systems able to perform analysis by examining context and surrounding words. This is of great relevance to the DNNs and DRL explored in the 2022 NUAA research. However, the research may not fully account for the additional reliability difficulties associated with the additional layering of data associated with neural networks. Unlike more standard or existing applications of AI, neural networks rely upon extensive layering and pattern recognition, something which can further increase the known reliability problems associated with AI. Therefore, if reliability is even more suspect or "challenged" with advanced, multi-layered neural networks, then the NUAA research may be overly optimistic about the premise that neural network-enabled "intercept avoid" is realistic in the near term.

**PLA Parallels U.S. Progress – In Flight Course Correction**

Despite what may be emerging differences in perception regarding the function of deep neural networks, there are clear parallels between PLA weapons development and U.S. progress in computer-enabled automation and tactical application. This would make sense in light of the widespread recognition that PRC weapons developers have at times been accused of trying to copy, replicate, or steal U.S. technological innovations.

The U.S. military has for years been successfully developing computer-automated and inertial measurement unit (IMU) enabled in-flight course correcting technology, such as the U.S. Air Force's Airborne Collision Avoidance System (ACAS). While this is different from deep neural network-enabled intercept avoidance, there are conceptual and technological parallels in terms of operation. The U.S. Army also has had success using IMUs, sensors, and computer-enabled "shaped trajectory" 155mm artillery shells capable of maneuvering and changing course in flight to, for example, hit a target in defilade, under a bridge, or on the other side of uneven, mountainous terrain. The Missile Defense Agency has worked with industry to engineer ICBM-intercepting exoatmospheric kill vehicles to use in-flight sensor discrimination to discern differences between decoys and actual ICBMs.

The research in the article published by NUAA seems to advance this concept and move beyond previous or existing technologies, applying AI-enabled neural networks and pattern recognition to discern high-speed HGV flight and interceptor guidance. The NUAA research proposes an AI-enabled method of operationalizing in-flight course correction guidance to avoid interceptor countermeasures and ensure an HGV continues on to destroy its intended target with precision.[19]

As opposed to course-correcting F-16s or 155mm artillery shells, HGV intercept avoidance suggested by Nanjing University leverages a new generation of deep neural network-enabled course-correcting technology. Unlike artillery or ballistic missiles, HGVs are known for maneuverability at speeds faster than Mach 5, and they often follow a non-linear or much less predictable flight pattern. These maneuvers are typically pre-programmed into the weapon prior to flight. This DRL proposal is intended to enable HGVs to aggregate and organize sensor data, perform analytics, make discernments regarding defensive interceptors and alter course autonomously in flight. Air attacks in the future are expected to occur at exponentially faster speeds, from much greater distances, and operate with paradigm-changing precision and guidance technology. Emerging AI-enabled, information-driven modern concepts of war anticipate more dispersed, longer-range, multi-domain yet extremely precise methods of air attack.

There appear to be some parallels between the research being conducted by NUAA on HGVs and the Air Force Research Laboratory's collaborative autonomy weapons program known as Golden Horde, in large measure because they both seem to leverage advanced applications of AI-enabled computing at the edge. The AFRL effort involves integrating groups of bombs, each built with advanced algorithms and AI-enabled data processing, to essentially collaborate with one another in-flight.[20] This introduces a new sphere of tactical air approaches for attackers, as they can streamline air strikes capable of responding to or countering enemy movements, defenses, or countermeasure attempts to escape or avoid being hit.

For instance, perhaps enemy armored vehicles quickly learn of incoming attacks and seek to obscure their position using terrain features, rapid movement, or acoustic and thermal signature-reducing approaches to avoid detection. Much of this is a question of speed; if weapons are traveling longer distances, there is, of course, additional opportunity for enemies, enabled by high-speed sensors, to adjust to or counter incoming weapons. This is where Golden Horde comes in. As inbound groups of weapons will operate with a paradigm-changing ability to adjust to in-flight target updates and essentially counter an enemy countermeasure. This AI-enabled ability to instantly adapt to new variables, new sensor input, new target locations or new enemy movements in flight is fundamental to the concepts of operation outlined in NUAA's proposal to use neural networks and deep learning to enable an HGV to avoid intercept. In the case of Golden Horde, data analysis and exchange can be used offensively to track and destroy a moving or changing target, yet in the case of the NUAA research, AI-empowered data analysis would be leveraged to evade a defensive interceptor and improve the probability of the attacking HGV to reach its target.

**Hypersonic Defenses**

NUAA's research cites interceptor avoidance but does not necessarily specify the kinds of systems where interceptors would come from, so it's not clear if the research proposal accounts for some of the actual hypersonic defense systems currently in development. However, PLA assessments of U.S. hypersonic defenses are almost certain to influence Chinese thinking on intercept avoidance. A conceptual and technical understanding of hypersonic defenses would, it seems, be critical to identifying any evolving method of avoiding intercept.

For example, the Pentagon is making rapid progress with the hypersonic weapons defense system HBTSS. The Northrop Grumman technology works to establish a continuous track of fast-moving hypersonic missiles from beyond-line-of-sight by networking small satellites to one another.[21] HBTSS is designed to leverage a growing network of new, smaller, lower-altitude, low- and medium-Earth-orbit satellites operating as a "meshed" network of extended, long-range nodes capable of transmitting target-track specifics in real time. Should a target track on an incoming HGV be established with networked satellites in medium and low Earth orbits, the idea would then be to quickly network the threat data to an interceptor weapons system such as the Pentagon's now emerging Ground-based Interceptor.

In recent years, HBTSS has launched two interoperable satellites, each built by a separate industry partner. Specifically, the idea is to leverage space assets to provide fire control quality data down to a weapon system like GPI. The idea is to track otherwise beyond-line-of-sight targets enabling fire control to establish and maintain a track early in the weapons launch, striking it just prior to its descent.[22]

At the Space and Missile Defense Symposium in Huntsville, Alabama in 2021, Mike Ciffone, director, Strategy, Capture & Operations, OPIR & Geospatial Systems, Northrop Grumman, said that: "One method is obviously data fusion and doing what fusion implies, I need to get that data that comes from the satellites down to the ground and to weapons as quickly as possible. A method of doing that is potentially processing some of that data in real time to a weapons database and transfer that data from the satellite system down to the weapon."[23]

Some of the data processing, for instance, can potentially be AI-enabled and also performed at the point of data receipt, essentially wherever the incoming sensor data first arrives. Computer processing is becoming much faster and, of course, AI-enabled, a series of technical breakthroughs that enable incoming sensor data to be instantly analyzed, organized, assessed, and streamlined. With this, key points, moments, or objects of relevance can be identified and sent to commanders at speeds exponentially faster than previously possible. This means that critical data such as anticipated flight path, landing time, location, speed, and altitude can be calculated by advanced computer algorithms. These algorithms support an AI-system able to bounce incoming specifics off of a huge, seemingly limitless database to make comparisons, examine similar past scenarios, and establish near real-time analytics. It incorporates an ability to organize data, find optimal courses of action, and relay them to human decision makers through a fire-control, sensor-to-shooter loop that is exponentially faster than what had previously been possible. Most of all, it enables a fast exchange of information across previously disaggregated areas or segments of detection not otherwise integrated to one another.

## Glide Phase Interceptor

The GPI is a developmental program to engineer a high-altitude, long-range missile capable of being fired from the ground or the deck of a Navy ship to intercept a hypersonic missile during phases of its flight when it might be more vulnerable to destruction.[24] By integrating GPI fire control with HBTSS sensing, the interceptor can launch toward an identified moving HGV target. If the weapon is traveling so quickly that it transits from one segmented radar field of review in a certain geographical region to another at unprecedented speeds, the tracking information may not be shared fast enough to enable an interceptor to "lock on" to its flight path. This challenge, and the fast-evolving solutions being engineered to address it, was a high priority for senior Pentagon weapons developers as far back as 2021. General John Hyten, former Vice Chairman of the Joint Chiefs of Staff, told an audience at the 2021 Space and Missile Defense Symposium that "We have to see something before it comes, so I'd like one capability that will allow us to see these threats globally at any time. We can build a space architecture that can see different threats such as hypersonics, cruise missiles .. and identify what those threats are."[25]

The Pentagon is working to solve this problem, and it is one reason why early conceptual and computer simulation work on the GPI is being done in coordination with HBTSS. The MDA awarded concept and design GPI deals to Raytheon, Lockheed, and Northrop Grumman with the intent of strengthening what agency officials describe as a layered defense. In September of 2024, Northrop Grumman became the GPI prime contractor. HBTSS could help find targets for the GPI and potentially pass them along in seconds while a hypersonic missile is traveling to its target. MDA descriptions of the GPI concept explain that the GPI fits into the MDA's missile defense architecture to provide the warfighter and its allies with reliable layered defense against regional hypersonic missile threats from rogue nations. It also seems conceivable that the GPI could be employed to intercept weapons from rival or great power nations as well.

## Aegis Ships, GPI and HBTSS

The GPIs are being slated to fire from ship-integrated Vertical Launch Systems using Aegis weapons systems, yet the targeting details can first come from space sensors such as HBTSS, which Northrop Grumman developers described years ago as an integrated constellation.[26] "We found that we can close the fire control loop with an Aegis ship that has already proven queuing launch-on-remote and engage on remote capability," Hill said.[27]

Launch-on-remote is an advanced fire control technology system wherein interceptor missiles can be directed from dispersed locations through networking, enabling new range and delivery options for firing interceptors. Launch-on-remote is something that became possible in recent years through upgrades to ship-integrated Aegis radar systems and networking developments enabling dispersed assets to pass targeting information and other crucial data to launch interceptors. Given the speed at which hypersonic missiles travel, it could otherwise be difficult for separate radar apertures or fields of view to pass target tracking flight details from one geographical segment to another, given the pace with which hypersonics can transit from one major area to another. This creates an essential need to establish a steady, continuous target track sufficient to target and destroy the missile. A hypersonic boost-glide weapon, for example, is thrust up into the atmosphere to glide at hypersonic speeds before descending upon its target at unparalleled speed. It is at this "glide" point in the missile's trajectory where there is the best opportunity to intercept it, just prior to its turning down into its ultimate high-speed descent. Navy Vice Admiral Jon Hill, former Director of the Missile Defense Agency, said in 2021: "So when you're in the glide phase—which is higher up from the terminal, right, where a hypersonic vehicle is likely in its most vulnerable phase—that's actually a pretty tough environment to be in. And you can't take an air defense weapon and operate it there nor can you take a space weapon like an SM-3 and operate there, it's just a different environment." [28]

At this time, Hill explained that the MDA was "maturing technologies" and working with industry to evolve "seekers and materials for operating" in that portion of the atmosphere, as well as exploring propulsion techniques to succeed in firing an interceptor capable of reaching and destroying a hypersonic weapon during its glide phase. Initial thoughts were that a GPI might not come to fruition until the 2030s. However, several promising more recent developments now indicate that the arrival of this kind of technology may be sooner than expected, such as in 2029. This is due to the resulting data collected from live fires during experiments on ship-based Aegis radar models and ground systems.[29]

**Conclusion**

It seems feasible that the intercept avoidance NUAA research may involve an effort to counter key use systems such as HBTSS and GPI, systems that are likely to inform the Pentagon's Golden Dome effort. Both the U.S. and China appear to be progressing rapidly with the application of deep neural networks to weapons systems. However, it remains unclear whether PLA HGVs are now capable of intercept avoidance. There are many apparent reasons for potential skepticism regarding the operational integration of deep neural networks in this capacity. Initially, there is the aforementioned complexity associated with the integration of unlabeled data in a multi-layered deep neural network. Reliability for advanced AI systems seems to remain a challenge with cutting-edge industry efforts to solidify AI-enabled DNN operational utility.

Secondly, there is reason to consider that the U.S. military continues to advance and harden its hypersonic defenses to increase the speed of detection and improve seeker technology and target verification of HGV intercept. One possibility is that guidance systems on a weapon such as GPI could potentially spoof or confuse PLA-generated deep neural networks by providing inaccurate information while simultaneously retaining its own guidance technology. Secondly, satellites in medium and low Earth orbits  are proliferating at such a rate as to build in redundancy and resiliency; this suggests that a maneuvering PLA HGV could potentially be tracked by multiple space sensors simultaneously, increasing the probability that an interceptor would have occasion to pursue accurate targeting information or adjust its flight path to ensure intercept. There is also the distinct possibility that satellite and seeker-driven HGV targeting can use its own AI-enabled DNN networking system to, in essence, adjust to HGV course corrections and overcome an attempted "intercept avoidance" such as that proposed by the Nanjing University research.

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**Technical Terms Glossary:**

**Intercept avoidance** – The ability of a Hypersonic Glide Vehicle to "avoid" being "intercepted" by a defensive interceptor missile

**Deep Reinforcement Learning (DRL)** - a machine learning technique where an *agent* learns to make optimal decisions in an *environment* through trial and error to maximize cumulative *rewards*

**Deep Neural Networks (DNN)** – an artificial neural network with multiple hidden layers between the input and output layers

**Adaptive guidance** – An ability to change course in flight using advanced AI-enabled maneuvering without needing human intervention.

**Zero Trust** - Pentagon effort to improve AI-reliability

**Autonomous retargeting** – An ability for a weapon or interceptor to receive, process and adapt to new target information while "in-flight."

**Trajectory optimization** – The effort to engineer and program a hypersonic glide vehicle to follow an unpredictable, high-speed flight pattern to avoid intercept.

## Endnotes

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