DGAPkompakt

Nr. 4 / March 2019

Technology and Strategy:
Hypersonic Weapon Systems Will Decrease Global Strategic Stability – and Current Control Regimes Won't Do

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Hypersonic weapon systems will alter the global strategic landscape. They will compress reaction times, increase ambiguity of military actions, and may lead to the weaponization of space. With no effective defenses against such systems in sight, all actors will face less stability – regardless of whether or not they field hypersonic weapon systems themselves. Germany and Europe should explore options to mitigate these risks through arms control, export controls, and confidence-building measures.

On the Brink of a New Arms Race

In December 2018, Russia attested a new weapon system: a nuclear-capable hypersonic glide vehicle named Avangard, which President Putin described as a "wonderful, perfect New Year's gift for the country."[1] This test was only the latest step in a dynamic harboring serious characteristics of an arms race; a situation where two or more actors are developing specific weapons with reference to developments of the other. Besides Russia, China is working on its own hypersonic glide vehicle called WU-14, which is scheduled to begin operations in 2020. The USA has conducted and is currently conducting tests with both hypersonic glide vehicles and cruise missile capable of flying at hypersonic speeds. All three countries defend their research, development and testing activities for these weapon systems as necessary to outperform the military capabilities of potential adversaries. For Russia and China, this adversary is the USA – and vice versa.

Technology and Strategic Consequences

Hypersonic flight refers to flight speeds around or above Mach 5 (5.500 km/h) and up to about Mach 20 (up to 22.000 km/h). Currently, three main types of weapon systems are in development which are envisioned to reach hypersonic speed: hypersonic aircraft, hypersonic cruise missiles (HCMs) and hypersonic glide vehicles (HGVs). Hypersonic aircraft and HCMs are essentially advancements of current systems. HGVs are unpowered gliders which are brought to the necessary heights by conventional ballistic missiles and then descend upon their target with significantly higher maneuverability than existing re-entry vehicles. Compared to their predecessors and similar systems, the fast cruising speed will make all three types more survivable against air defense systems.

Three main effects of hypersonic weapon systems stand out: First, their ability to engage targets even if they are covered by sophisticated air defenses at a time when such air defense systems are proliferating globally. Second, they have the potential to further enhance the range and capabilities of Anti-Access/Access-Denial (A2/AD) weapon systems. However, it is the third effect which entails the most challenging consequences in a strategic sense: Hypersonic weapon systems could be used to conduct decapitation strikes or first-strikes on strategic

weapons, especially nuclear arms. This would endanger the delicate equilibrium between the nuclear powers that evolved with the conception of second-strike capabilities and doctrines such as Mutual Assured Destruction (MAD).

Abundant Technological Challenges

As with most technologies still maturing, both technological challenges and failure rates in flight tests are quite high. Currently, no hypersonic weapon system or commercial application has completed the experimentation phase. The earliest introductions into operational service are planned by China and Russia with their HGVs in 2020. Timelines for the future military use of other systems range from ten years for HCMs to 20-25 years for hypersonic aircraft.

Four main technical challenges characterize hypersonic flight: The intense heat occurring at hypersonic speeds cause the physical deformation of components, influencing flight characteristics and maneuverability. Moreover, high temperatures cause the ionization of the air which envelops part of the object. This impedes flight control and renders communication with the aircraft or missile highly difficult. With regard to propulsion, in the case of aircraft and HCMs, the main technical challenge is to integrate engine characteristics capable of slower flight for start and landing with those needed for hypersonic flight. Lastly, current testing facilities and computer simulations cannot perfectly simulate the operational environment of objects flying at hypersonic speeds. Hence, real flight tests are necessary for further development, which significantly increases costs and technical requirements.

Innovation does not only have to come from military research: Many results of ongoing state-funded civilian research and commercial efforts into hypersonic technologies will have a dual use. They can also be used to develop or improve hypersonic weapon systems, since the main problems with hypersonic flight today stem from fundamental technologies such as propulsion and materials rather than weapon-specific parts.

Widespread Interest in Technology Makes Proliferation Likely

Currently, the USA, Russia and China are on the forefront of the development of hypersonic weapon systems, with France following with some distance. Additionally, the European Union and Japan are very active in civilian research and development activities related to hypersonic technologies such as hypersonic passenger aircraft in the future. Lastly, commercial companies are interested actors, with some of the most ambitious projects for future hypersonic aircraft located in the United Kingdom. All these activities highlight widespread interest in the technology and, for some actors, in their military application, which makes future proliferation of hypersonic weapon systems more likely.

The three major players in the development of hypersonic technologies demonstrate different stages of maturity for hypersonic weapon systems: While the USA are in the lead and are developing all three types of hypersonic weapon systems, Russia and China appear to be focusing on the development of HCMs and HGVs, respectively. This divergence stems from the different capability levels of the domestic aerospace industries where the USA has a free hand to explore all options given its sophisticated industrial base and access to the most resources. An experienced – albeit ultimately constrained – industry allows Russia to focus on the difficult development of HCMs and HGVs, while China as an industrial "newcomer" eyes the operational use of the least sophisticated hypersonic weapon system (HGVs).

Strategic Implications

Introducing hypersonic weapon systems into active service in one or more states will alter the global strategic landscape. Four changes are likely to occur: compressed reaction times, increased deterrence effect, increasing ambiguities of military actions, and lastly, second-order effects such as the further proliferation of hypersonic weapon systems and the weaponization of space. Each of these factors will invariably decrease strategic stability between states, regardless of whether or not they field hypersonic weapon systems themselves.

Time Compression Decreases Stability

The higher speed and lower visibility of hypersonic weapon systems compared to their predecessors cause the most apparent change in the strategic landscape. Current lead times for attacks with ballistic missiles range between twenty and thirty minutes (e.g. for an attack by Russia on the US) and thus provide military and civilian authorities with a window of opportunity to decide within that timeframe. Hypersonic weapons will shrink that timeframe considerably to as few as five minutes. Even this very short timeframe would only apply if there are long distances involved (for instance, Russia to the USA instead of Pakistan to India) and when the attacked country has quite sophisticated early warning systems in place, especially space-based early warning systems. If this is not the case, timelines for detection, decision-making and reaction shrink even further.

To – at least marginally – compensate for this loss in decision-making time, actors will have to employ faster

intelligence-gathering and decision-making, potentially by automatizing and autonomatizing parts of these processes. The pressure on decision makers who determine whether or not to launch a retaliatory strike will increase exponentially.

Consequently, in many states, time compression might lead to force postures aimed at ensuring a second-strike by launching retaliatory strikes on warning. This would allow that a retaliation strike can be conducted before the incoming hypersonic weapons destroy or seriously reduce the overall second-strike capability. Since early-warning systems are error-prone and might issue warnings due to technical errors, launch-on-warning force postures significantly increase the risk for escalation and thus war. They reduce both strategic and crisis stability between states.

Putting Forces at Higher Risk

Since hypersonic weapon systems are more capable than comparable current systems, they will put military forces at higher risk for an attack – especially as no actor today has an effective defense against such fast-moving missiles and aircraft. Their introduction thus incentivizes the dispersion of forces to reduce losses should an attack occur. This complicates verification and inspections; in the framework of arms control regimes, for example.

Moreover, hypersonic weapons will also influence the survivability of conventional forces: Anti-ship missiles based on hypersonic designs might enhance the lethality and size of A2/AD zones. Moreover, forward deployed forces in Forward Operational Bases (FOBs) that seldom have sophisticated air defenses are at greater risks.

Increasing Ambiguities Favor Worst-Case Thinking

Lastly, hypersonic weapon systems and especially HGVs aggravate several ambiguities which might lead to miscalculations on the side of an adversary. This is due to their use of ballistic missiles for launch and in-flight maneuverability.

Warhead ambiguity describes the uncertainty about whether an incoming missile or HGV is armed with a conventional or nuclear warhead.

Destination ambiguity signifies that the destination (in this case, country) of hypersonic weapons is unknown – compared to current ballistic missiles which largely follow a physically determined flight path. Such a flight path allows for early calculations, while HGVs can maneuver and thus change their destination in flight.

Target ambiguities become relevant when the destination is largely determined, but the question remains what kind of target is to be attacked. For instance, if nuclear second-strike capabilities are targeted, this might incentivize the attacked actor to launch these weapons for a retaliatory strike, even if it is not certain that the incoming strike is directed towards these second-strike weapons.

Such ambiguities about warheads, destinations and targets likely lead attacked actors to assume the worst, especially when it comes to their second-strike capabilities. These capabilities are prime targets for any incoming strike and the only viable tools for the attacked actor to retaliate sufficiently. Consequently, decision-makers will have to make fast decisions for or against retaliation strikes since capabilities such as nuclear weapons are "use it or lose it" weapons.

Triggering Proliferation and the Weaponization of Space

A widespread introduction of hypersonic weapon systems into service could also have the second-order effects in that more countries strive to possess such weapon systems – which cannot be in the interest of countries aiming to increase global strategic stability. Moreover, all countries, whether or not they possess hypersonic weapons themselves, would be incentivized to disperse and decentralize their forces, command, and control networks. In all likelihood, even more efforts will be poured into advanced air defense systems, which might lead to their further proliferation. More countries would seek to establish space-based early warning systems capable of detecting missile starts as early as possible to maximize lead time. Lastly, as US President Trump announced in January 2019, even space-based missile defense systems might make a comeback.[2] In so doing, he opened a Pandora's box for the weaponization of space.

An Array of Options

Arms control instruments, non-proliferation treaties, confidence and security-building measures (CSBMs) and the build-up of advanced defense systems are the primary options for Germany and Europe to react to the emerging hypersonic weapon systems. Most existing structures in these categories are insufficient for hypersonic weapon systems and require adaptation or the introduction of new structures. This is especially true when it comes to the actors: China is not part of any of the major regimes capable of reigning in hypersonic weapon systems and their proliferation.

Increasing Stability through Arms Control

Current arms control regimes could partially cover emerging hypersonic weapon systems once introduced into service. However, they do so only to an insufficient

degree, indirectly, within constrained geographical areas, and only for certain actors. Furthermore, some of these regimes, especially the Treaty on Conventional Armed Forces in Europe (CFE Treaty) and the Intermediate Range Nuclear Forces (INF) Treaty are facing irrelevance or looming obsolescence. Even the future of the New START (Strategic Arms Reduction Treaty) is unclear, which regulates the arsenal of strategic nuclear weapons and their delivery systems between Russia and the USA and which is scheduled to expire in 2021.

it will depend on the length of the boost-phase of future operational HGVs whether or not they would be covered by New START. The United States has even stated that boost-glide weapons fall outside of the definition of ballistic missiles which would prevent coverage by New START. The INF Treaty prevents the use of HGVs in addition to ground-launched ballistic missiles with intermediate and short ranges by banning such systems altogether. However, its reach is limited with the USA and Russia as the only treaty parties and its likely end later in 2019.

Table 1: Arms Control and Non-Proliferation Coverage of Hypersonic Weapon Systems by existing regimes

		Arms Control regime		
		CFE	INF	New START
Type of Weapon System	Aircraft	Partially	Not covered	Not covered
	HCM	Not covered	Indirect, ground-launched cruise-missiles with short to intermediate range	Not covered
	HGV	Not covered	Indirect, ground-launched ballistic short and intermediate missiles	Indirect, ground-launched intercontinental ballistic missiles

Hypersonic aircraft used for military purposes (except for training) could be regulated by the CFE Treaty, Article II, section K. At the same time, the CFE Treaty is only of limited use in this particular case. This is because although hypersonic aircrafts could be stationed well outside of Europe, they could still engage targets in European theaters as they will likely feature long-range and high speed. Hence, they would not count as assets under CFE regulations. Even if some states were to decide to station them within the area of application of the Treaty, no participating member state of the CFE Treaty is near the ceilings for combat aircraft negotiated under its terms.

At least in the way they have been conceived until now, hypersonic cruise missiles are not affected by any existing arms control regimes. Even though their range and profile would make them viable subjects for a ban by the INF Treaty, current designs are exclusively air-launched. The INF Treaty might be applicable to future hypersonic cruise missile systems if they are to be ground-launched. However, such systems will probably only emerge in the next decade. Given the anticipated termination of the INF Treaty this August, it is likely unable to regulate such future weapon systems but might serve as an example for future arms control treaties.

HGVs would fall under the New START or the INF Treaty. Since the former not only covers nuclear warheads but also delivery systems, and since HGVs are dependent on ballistic missiles for their boost-phase, New START directly impacts the maximum possible quantities of operational HGVs. However, New START only includes weapons if the majority of their trajectory has a ballistic character. Hence,

Hence, it is likely that new regimes will have to be developed and negotiated to curb the destabilizing effects of hypersonic weapon systems. Most importantly, such initiatives would have to include countries with limited experience in arms control such as China. Unfortunately, the current international political environment makes the adoption of such new regimes very unlikely.

Hampering Proliferation with Non-Proliferation Regimes

Non-proliferation efforts could accompany the development of new arms control regimes. Limiting the export of hypersonic technologies would be highly effective in curbing their proliferation since the technologies are still challenging even for the most advanced countries and their aerospace industries. Here, the Missile Technology Control Regime (MTCR) or the Wassenaar Arrangement offer sound bases for either expansion or the conception of a new regime. What makes non-proliferation efforts difficult is the dissemination of civilian research results on hypersonic flight, and adjunct technologies, Moreover, both the MTCR and the Wassenaar Arrangement suffer from the same main weakness: the limited number of participating states, with key countries such as China currently absent from the arrangements.

Beyond Arms Control and Non-Proliferation

Measures beyond rather traditional arms control and non-proliferation mechanisms can also be used to mitigate the effects of hypersonic technologies and weapon systems, especially mitigating several of the ambiguities inherent

to these weapon systems. However, all of the following require extensive CSBM measures to provide sufficient security against potential adversaries:

1. At the least, HGVs and their respective carrier systems (ballistic missiles) could be deployed in different locations than strategic nuclear weapons in the form of ICBMs. This way, an adversary could know that it is not a nuclear, but "only" a conventional attack, reducing warhead ambiguity. Moreover, different carrier systems could be used for nuclear warheads than for HGVs.
2. Trajectories of such systems should be different. Such measures could decrease warhead ambiguity.
3. Predictable trajectories and observable midcourse trajectories for HGVs and HCMs could decrease destination and target ambiguities as well as limit the tactical surprise for an attacked country. However, as such changes to the technology would also negate its most critical military advantages, such a development is quite unlikely.
4. Voluntarily limited deployment of hypersonic weapon systems of all kinds might increase crisis stability, since no side would have to fear a massive deployment of such weapons, potentially engaging and reducing or destroying second-strike capabilities.
5. Countries with active hypersonic weapon systems could agree on a voluntary targeting ban, thus ruling out the engagement of certain targets (nuclear weapons, for instance) with hypersonic weapon systems. However, given that this would significantly diminish the return on investment on these weapon systems, this is unlikely to be politically feasible.
6. A test ban for hypersonic weapons similar to the Comprehensive Nuclear-Test-Ban Treaty (CTBT) could be utilized to curb further military investments. Given the still largely experimental status of hypersonic weapon systems, an effective test ban would very likely prohibit their actual introduction into active service. This is because such an introduction without extensive testing would not be in the interest of any armed forces which require reliable systems.
7. It is possible to react by introducing air defenses against hypersonic threats. Today, the most advanced air defense systems can engage cruise missiles and short-to-medium range ballistic missiles. Additionally, some states, first and foremost the USA, are working on Ballistic Missile Defense (BMD) systems to protect against long-range ballistic missiles. However, given the extreme velocities of hypersonic weapons, the technical challenges to intercept such flying objects are enormous and would require costly research and development programs which would focus on hypersonic missiles as interceptors – or even more technical challenging assets such as lasers.

Focus on the Most Dangerous Weapons

Germany and Europe have two significant reasons for aiming to curb the destabilizing effects of hypersonic technologies and weapon systems in particular: First, time compression and subsequent effects caused by such systems are even more dangerous if applied to the European continent, in contrast to most intercontinental (transpacific) scenarios currently discussed. Second, as Germany and Europe generally favor stability and de-escalation especially among nuclear powers, decreasing strategic and crisis stability could never be in their interest.

Time and prioritization are key factors in guiding the practical use of limited political and diplomatic resources. Since hypersonic weapon systems are in various stages of development and have different impacts on strategic balances and crisis stability, efforts should focus on regulating HGVs first, then HCMs, and lastly, hypersonic aircraft. Given that all these types decrease strategic or crisis stability, it is desirable to apply arms control and non-proliferation mechanisms to them. Fortunately, the underlying technologies are still in the experimental state across the world, which might reduce the political resistance to arms control measures today as opposed to a time when these systems are deployed and operationally active.

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Notes

1 Paul Sonne and Anton Troianovski, "Russia is poised to add a new hypersonic nuclear-capable glider to its arsenal," *Washington Post* , December 26, 2018 <https://www.washingtonpost.com/world/europe/russia-is-poised-to-add-a-new-hypersonic-nuclear-warhead-to-its-arsenal/2018/12/26/e9b89374-0934-11e9-8942-0ef442e59094_story.html?noredirect=on&utm_term=.00417c03ce8d> (accessed on March 11, 2019).

2 Lolita C. Baldor and Deb Riechmann, "Trump says US will develop space-based missile defense," *Associated Press News*, January 17, 2019 <https://www.apnews.com/33e12cf640a6408bb11aa3defa864966> (accessed on March 11, 2019).

DGAP**kompakt** / Nr. 4 / March 2019

DGAP
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Publisher *DGAP e.V.*
ISSN 1611-7034

Editing Eva-Maria McCormack, Hanna Bianca Krebs
Layout Reiner Quirin
Design Concept Carolyn Steinbeck · Gestaltung