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New Hypersonic Weapons: Same but Different

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Hypersonic weapons can increase pre-emption fears and dangerously alter crisis escalation scenarios by the 2030s. This popular argument builds on the expectations that their unpredictable flight path create target ambiguity, radars do not cope well with their unusual altitude, and their extreme speed decrease defender's time to react. While existing ballistic missiles do cross the hypersonic threshold of Mach 5, new hypersonic weapons – both glide vehicles and cruise missiles – are intended to fly at sustained hypersonic speeds within the atmosphere and have the agility to change their flight trajectory. However, the military utility of hypersonic weapons remains unclear, especially in case of long-range systems, and their reliability and feasibility still necessitate rigorous testing. It is likely that hypersonic weapons would create new military effects only at tactical ranges, mostly due to their speed shortening the defender's reaction time.

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- The current NORAD infrastructure is not sufficient to address the widening spectrum of missile threats. The reputed invincibility of hypersonic weapons should not prevent Canada from affirming its strategic choices. Neither should it undermine its resolve to modernize NORAD. The Government of Canada should address the issue of hypersonic weapons along two policy lines.
- First, in coordination with the United States, Canada needs to increase the protection of the North American airspace. The North American continental area defense will need to be multilayered and integrated, linking ground and space-based sensors with ground and air-launched countermeasures for fast detection and persistent tracking, while enabling effective interception. This requires not only improving early warning coverage and upgrading command and control communication systems, but also introducing new missile interceptors. The already approved investment in NORAD modernization creates room in Canada for both adding capabilities and expanding its mandate.
- Second, to counter politicizing and hyping of hypersonic weapons, the Government of Canada should work with its allies towards improving the understanding of hypersonic threats. Instrumentalizing hypersonic technology for the great power competition has created exaggerated expectations regarding the military effects of hypersonic weapons. As the technological race among the United States, China, and Russia is spiraling, Canada and its allies need to speed up their efforts to update the arms control and export norms to better regulate the development and use of hypersonic technology for military purposes, as well as control its proliferation.

Introduction

The Russian missile threat has increased in Europe after the demise of the INF Treaty in 2019, with deploying Kinzhal air-launched ballistic missiles in Kaliningrad, the Russian exclave bordering NATO members Poland and Lithuania. In addition, the Avangard hypersonic glider system is able to hit the North American continent. Hypersonic weapon systems as new delivery vehicles for nuclear and non-nuclear warheads are also gaining importance in the context of China's assertive policy to augment its nuclear arsenal to 1,000 warheads by the end of this decade.

Exaggerated expectations – and in turn inflated budget lines securing investment in new weapons – about the military hypersonic capability are worsening the security environment. The intense technological race among the United States, Russia, and China, and to a lesser extent in Australia, South Korea, India, France, the United Kingdom, and Japan, but also North Korea and Iran, has aggravated the security dilemma. As this emerging technology has gained a reputation of an invincible and unstoppable weapon, countries are trying to build themselves out of the perception of their own vulnerability by either parading them at military shows and in ongoing conflicts or at weapon test spectacles.

Once the new hypersonic technology matures by the 2030s, how effective will the North Warning System (NWS) radars be against vehicles flying at extreme speeds and unusual altitudes? The defensive role of the North American Aerospace Defense Command (NORAD) currently supported by Canada will not be enough to counter advanced long-range cruise missiles and hypersonic gliders. However, exploiting the lesser-known trade-offs among speed, maneuverability, and altitude offer ways to strengthen defenses against the hypersonic threat.

This piece puts forward three main points. First, claims about the military utility of hypersonic weapons are premature, especially in case of long-range systems. Second, the spectrum of missile threats – the variety of high-speed, maneuverable threats from the sky – has been widening. And third, technological competition has become politicized, with hypersonic weapons serving as a political tool to demonstrate technological prowess and great-power status, which results in increasing the risks of crisis escalation. For these reasons, it is important to tame the exaggerated expectations about the military application of hypersonic technology and rethink how Canada does air and missile defense.

Hypersonic threat in making

Hypersonic weapons are presented as a new class of delivery vehicles that can travel at extreme speeds (five times the speed of sound) in the Earth's atmosphere and have an outstanding ability to maneuver. They are being advertised as weapons that combine the advantage of both existing ballistic (speed) and cruise (accuracy) missiles.

Hypersonic weapons come in two main variations, relying either on air-breathing technology or boost-glide technology. First, hypersonic cruise missiles (HCM) are a faster version of existing cruise missiles, as they are powered by an air-breathing supersonic combustion ramjet engine, also called a scramjet. Because air-breathing engines get the necessary oxygen directly from the atmosphere, hypersonic missiles are smaller and more maneuverable. Since scramjets operate

under extreme conditions, it has been taking several decades to develop an engine that would work at a hypersonic speed within the atmosphere. Due to technical challenges, today there are no deployed weapon systems using a scramjet engine.

Second, hypersonic glider vehicles (HGV) are unpowered and depend on a rocket to be lifted and released in the atmosphere at altitudes between 40-100 kilometers, after which they fly down unpowered to their target. Unlike the easily calculated bullet-like trajectory of ballistic missiles, the boost-glide concept makes the re-entry altitudes of HGV unpredictable and enables the glider to maneuver along convoluted routes.

Most HGVs in development use ballistic missiles during the boost phase. In 2021, China mounted a hypersonic glider on an orbiting rocket, inspired by the Soviet Fractional Orbital Bombardment System or FOBS (operational from 1969 to 1983). The novelty of this system does not lie with the combination of an orbiter and a hypersonic glider – this type of system has been around for decades known as a rocket-powered space shuttle that is lifted by a rocket, goes into an orbital flight mode, and then glides back – but with the fact that China allegedly attached a nuclear warhead to it.

In a nutshell, the characteristics of new hypersonic weapons are thought to create a moment of surprise as they shorten the defender's time to react, and since they can change flight direction at unusual altitudes, they can evade missile defenses and confuse the defender about their target. To spice things up, these weapons does not have to rely only on their kinetic energy to cause damage, but also can carry a warhead. Both Russia and China are developing dual-capable platforms, that is the ability to carry both nuclear and conventional warheads; for instance, Russia's hypersonic cruise missile 3M22 Tsirkon with a range of 1,000 km and China's 2,500-km-range ballistic missile DF-17 as well as intercontinental ballistic missile DF-41 fitted with hypersonic gliders. The offensive hypersonic capability is thus expected to bring along warhead and target ambiguities.

Bending the laws of physics

This all sounds rather terrifying, yet the state of technology research and the laws of physics counsel skepticism. From the technical perspective thus, mastering hypersonic capability, that is the ability to fly hyper fast within the atmosphere while retaining navigability and maneuverability, is a matter of rocket science. The scientific community estimates that HGVs and HCMs will not be operational before the 2030s and the 2040s respectively. This is because countries that wish to field these weapons still need to engineer out some important details regarding the challenge of flying hypersonic in the thick atmosphere. Namely, the heat created by the air friction at such high speeds can melt the vehicle away, mess up its navigation, or make the vehicle visible to the heat-seeking infra-red sensors that could track the missile (or glider), ruining the advertised surprise effect of hypersonic systems. At the same time, these vehicles are sensitive to any surface imperfections; for instance, the crack in the carbon panel caused the returning Columbia space shuttle to crush. Not less importantly, powered hypersonic flight is more fuel-demanding than supersonic, since the vehicle needs to perse through thick atmosphere. This increases the operational costs of the weapon system.

Hypersonic business is costly in time and resources. New hypersonic weapons need further testing, but their technical requirements already make them niche capability. Flying hypersonic in the atmosphere implies important trade-offs in terms of speed, altitude, maneuverability, and accuracy. Importantly and rather surprisingly, two points are usually omitted in the public debates about hypersonic weapons: their questionable military utility and the possibility of countermeasures.

Feasible and somewhat useable

First, while hypersonic weapons may be technically feasible, their military utility especially at strategic ranges remains unclear. From the military perspective, the question of what problem new hypersonic weapon systems are trying to solve remains unanswered. Hypersonic missiles have been around for several decades, they are just better known as intercontinental ballistic missiles (ICBMs). Technically, all ballistic missiles with a range longer than a few hundred kilometers are hypersonic since they can fly faster than Mach 5. For instance, the US Minuteman III, operational since 1970, can travel over 9,600 kilometers reaching Mach 23. Studies based on computational modeling have shown that the speed and range of hypersonic gliders are comparable, if not inferior, to existing ICBMs and submarine-launched ballistic missiles.

The strategic advantage of hypersonic weapons is therefore likely to be minimal. Depending on where you stand, hypersonic weapons either reinstate or eliminate mutual assured destruction. The argument in favor of strategic hypersonic weapons puts forward that they enhance deterrence by improving second-strike capabilities. In contrast, these weapons can erode deterrence by enabling the country to overcome missile defenses and take down the adversary's second-strike capability.

Indeed, for Russia, long-range hypersonic gliders represent a qualitatively new capability for overcoming US homeland defenses. Even though the advantage of hypersonic weapons is weakest at intercontinental ranges, for Russia they represent a hedging strategy. In contrast, China has been developing hypersonic weapons to further project its power in the South China Sea and over Taiwan, circumventing US missile defenses in the Asia-Pacific region. The Chinese fear of a US pre-emptive strike that would disable China's nuclear capability and deprive China of its ability to retaliate seems to be the motive behind fitting its DF-41 with multiple gliders.

However, both China and Russia already have the capability to reach US soil with their ICBMs and nuclear submarine-launched ballistic missiles. In addition, continental missile defenses against the existing long-range ballistic missiles have not been known for their stellar performance. Yet the obsession about outsmarting the US network of air and missile defenses led to the extreme case of China's testing a space-based hypersonic glider. Inspired by the FOBS, China has demonstrated that it can evade US missile defenses completely by flying over the South Pole. However, this orbital boost glider system might be just China's signaling of its access to space, and a distraction from the potentially more consequential use of hypersonic weapons at tactical ranges.

Hypersonic effects will most likely be felt on the sub-strategic level. This may include the ability to frustrate local defenses and to provide rapid strike capabilities against locally deployed armed forces, especially in naval warfare, and high-value, time-sensitive, and hardened targets. Both Russia and China intend to acquire anti-ship missiles that can make even aircraft carriers vulnerable, such as Russia's 3M22 Tsirkon and China's Starry Sky-2 (or Xing Kong-2). These

hypersonic systems may have strategic implications due to their dual-capable delivery system. Discussing whether a country deploys nuclear weapons at supersonic or hypersonic speeds misses the point: the type of warhead makes the difference, not the speed.

Stopping the hypersonic threat

Second, hypersonic missiles are stoppable. Although countering hypersonic threats will be challenging due to their high speeds, maneuverability, and flight altitudes, their infra-red signature and vulnerabilities of hypersonic flight in the atmosphere make especially the glide-phase interception workable. However, it would require a major improvement to the space sensor architecture and new interceptor capabilities to account for the operating altitudes (20-100 kilometers), unpredictable trajectory, and the speed of hypersonic weapons.

Upgraded defense systems will need to be layered, integrated, and continent-wide, and go beyond ballistic missile defenses. Existing air and missile defense systems mostly rely on the ground- and sea-based radars for early warning, which are not equipped for persistently tracking hypersonic weapons. Hypersonic weapons are expected to fly at lower altitudes, that is below the altitude of ballistic missile interceptors and low enough that the curvature of the Earth obscures them from ground-based radar detection, but above the altitude of the lower layered air defenses. Effective air and missile defense systems would need to connect space-based, heat-seeking eyes of infra-red sensors with the upper layer intercept outside the atmosphere with the lower layer intercept within the atmosphere for a global detection and tracking capability of a hypersonic threat. Indeed, the US Missile Defense Agency (MDA), together with the Space Development Agency, has been developing a constellation of low-orbit surveillance satellites with sensors for launch indication and warning. MDA has also initiated efforts to realize a Glide Phase Interceptor, a new prototype missile to be paired with the Aegis ballistic missile defense system.

Infra-red signatures and the plasma around hypersonic vehicles could already allow Patriot and THAAD defense systems to detect hypersonic weapons during the glide phase when they operate within the atmosphere and at lower speeds. Their software and propulsion adaptation may offer a capability for shorter-range glide-phase intercept. However, while these defense systems could be adapted to intercept hypersonic weapons, they can cover only small areas and it would be prohibitively expensive to use them for continental defense. Yet any effective defense against fast-flying, maneuvering missiles would likely need to be continent-wide. This will require cooperation among allies and, ultimately, with Artificial Intelligence as the new defense systems will require new software tools to process multiple and fast intelligence data to detect weapon launches and track the incoming threats.

The crucial step will be to pair seamlessly the new early-warning space-based sensor layers in development, which will detect and track the heat signature in their brightest, earliest phases of flight on the one hand, with glide-phase effectors either relying on the upper-layer intercept, as provided by adapted Aegis and THAAD, or the lower layer (within the atmosphere) intercept, as provided by Patriot and SAMP/T systems on the other hand. Since hypersonic weapons operate in-between air and space domains, hypersonic weapons can have a significant impact on the effectiveness of air and missile defense systems.

Enter geopolitical competition

Given the persisting technological limitations, the current effect of hypersonic weapons has been mostly psychological in the form of strategic signaling, status projection, intimidation of adversaries, and propaganda. For instance, on this year's eve of the China's Army Day on August 1, Beijing publicly showcased for the first time a video of its DF-17 missile launch. This missile is known for its ability to carry a hypersonic glider since 2019. Although little is known about the operational status of this weapon, the launch video comes just a few days ahead of US Nancy Pelosi's visit to Taiwan, before testing the DF-17 missile system during a live-fire exercise in the Taiwan Strait.

Despite (or because of) having become a fading military power stuck in a war, Russia will have the Tsirkon hypersonic cruise missiles delivered to its naval forces, as announced by the Russian President. Most famously, the use of Kinzhal in Ukraine in March 2022, allegedly the first hypersonic weapon employed in wartime, demonstrated the Russian attempt at using a so-called hypersonic missile Kinzhal to fake its confidence. Kinzhal is essentially a propaganda weapon – an air-launched ballistic missile wrapped in a hypersonic cloak with no documented outstanding ability to maneuver. More accurately, it is a modified version of the surface-launched Iskander-M tactical ballistic missile, launched from a supersonic MiG-31 interceptor jet, which gives the missile a boost to reach higher speeds at an altitude that is unusual for a ballistic missile and extends its range.

Hypersonic weapons, and emerging technologies in general, have become a political tool of the government for propaganda purposes thanks to their reputation of an invincible weapon destined to intimidate and coerce the opponent, inflating fears, and distorting facts about their operational readiness. Regardless of the current lack of data and verified information about the reliability and performance of hypersonic weapon systems, both China and Russia have repeatedly claimed to have deployed these weapons.

Reportedly, Russia deployed its first hypersonic glider Avangard in December 2019. China declared its hypersonic glider DF-17 operational in 2020, while the United States claims to field its hypersonic weapons by 2023 and has been testing weapon prototypes only. Although the United States has been investing in hypersonics as part of the Prompt Global Strike program, the budget boost in hypersonic research in the past years from a few hundred million to a few billion USD is a reaction to the Russian and Chinese technological advances in fielding hypersonic weapon systems. This reflects the US perceived lack of advancement in the development of new offensive hypersonic weapons, rather than fulfilling an actual gap in its military capabilities.

Currently, hypersonic threats are not based on real military capability and do not convey any significant advantage. While hypersonic weapons could be technically possible within the next two decades, technical availability and technological feasibility do not automatically translate into sound military effects without the right doctrine.

Therefore, the hype about weapons is more dangerous than the technology itself mainly for two reasons. First, perpetuating the belief of invincible revolutionary weapons fuels the great power rivalry. Using the reputation of hypersonic weapons as a political tool to signal great power status,

especially at times of disappearing arms control norms, creates instability. And second, hypervelocity is only one of the features that will shape future warfare in the air and space domains. The hype highlights speed, while it should be maneuverability. This thus clouds the fact that the spectrum of missile threats is widening and that there are missiles with different degrees of maneuverability. For instance, instead of sensational but poorly defined hypersonic gliders, it would be more accurate to talk in terms of a new generation of a Maneuverable Re-entry Vehicle (MARV) that improve the maneuverability and extend the range of a missile while staying in the atmosphere for most of their flight.

Hypersonic implications for Canada and North American Defense

In contrast to technological determinism, manifested in the tech hype carrying the false promise of a revolutionary hypersonic weapon, the military needs a sensible doctrine and budget to finance hypersonic development projects , as much as the government needs a sound hypersonic technology policy. It remains vital to tame the drive for prestige and tech supremacy, which distorts countries' threat perceptions and increases the risk of crisis escalation. All three major weaponizers are planning to acquire hypersonic war-fighting weapons, which contrasts with their most vocal deterrence mission. Once the hypersonic technology matures, allowing weapon systems to become operational and yield added-value military effects, hypersonic capability will represent a major factor in detecting and intercepting missile threats.

The Government of Canada would be well-advised to address the issue of the hypersonic threat within the context of the widening spectrum of missile threats along two policy directions.

1/ Update missile defenses in coordination with the United States to protect the North American airspace.

Countries like the United States and Canada should focus their investment on hypersonic missile defense at short and medium ranges, as the spread of hypersonic gliders can undermine North American continental defense. Given the climate change affecting the Arctic security region, the ongoing war in Ukraine, and the spread of emerging technologies with little-known military effects, Canada should affirm its strategic choices and its resolve to modernize NORAD.

Recurrent concerns about the Russian threat in the Canadian Arctic, such as, for instance, the Russian bombers flying to the edge of the Canadian airspace, have nothing but increased since the Russian invasion of Ukraine in February 2022. In addition, although China is focusing on its regional supremacy, its hypersonic gliders, too, have intercontinental ranges. While the Russian and Chinese missile threats against the Canadian territory remain low, the Canadian government should rethink NORAD along the concept lines of a fully integrated air and missile defense system.

Future continental defenses will need to emphasize the multilayered and integrated area defense systems, consisting of well-connected ground and space-based sensors with ground and air-launched interceptors for fast detection and persistent tracking. This is because new missile threats

will travel across air and space domains, with greater maneuverability at extreme speeds and unusual altitudes. Crucially, the governments also need to invest resources into new interceptors. In addition, hit-to-kill intercept could be supplemented with electromagnetic (microwaves to damage the internal electronics of the missile) and cyber (jamming) countermeasures; yet due to the high-surface temperature of hypersonic vehicles, it is doubtful whether lasers could represent an effective means to stop the threat.

Canada's new 4.9 billion CAD investment into modernizing NORAD approved in June 2022 may include both adding capabilities and expanding its mandate. This would mean moving beyond upgrading the NWS – the over-the-horizon radar system to provide early warning coverage and threat tracking and modernizing command and control and communication systems – to include also new air-to-air missile interceptors, in addition to jets.

Carefully choosing the right interceptor mechanism will be important. While targeting the launch platforms and relying on fighter interceptors have been more popular, in the case of long-range hypersonic missiles and gliders interceptors need to target the vehicle itself with missiles. Therefore, investing in active defense, not only deterrence, and including ground-based area defense to protect high-value targets should become an inevitable budget line.

The current ground-based radars alone are insufficient since ballistic missiles will soon be only one of the threats against North America. Canada will need to make sure that NORAD is also able to protect against cruise missile attacks advanced in both range and speed, and gliders flying at unusual altitudes, which makes building the layers of space-based sensors crucial for their detection and tracking.

The US MDA already plans to realize a glide-phase hypersonic defense by the late 2020s (at the earliest though). Although Ottawa declined twice to participate in the US midcourse ground-based missile defense, due to nuclear weapons concerns – while supporting the NATO IAMD over Europe and NORAD's tactical warning and attack assessment role – the defense against hypersonic gliders may be more politically acceptable, not only because hypersonic gliders spend minimum time in space, but also participation would give Canada influence over decision-making in North America's defense.

2/ Work towards a better understanding of the hypersonic military capability and control its spread.

The politization of hypersonic weapons in the great power competition has created a gap in the understanding of hypersonic threats and the actual capability of hypersonic weapon systems. Great powers are not only tech mirroring each other, but purposefully exaggerating the capabilities of weapons systems still in development, as well as exploiting these distorted perceptions for propaganda. The dangerous technological race is spiraling as China tested an orbital rocket with a glider, the United States shortly after announced building multiple space-based sensor layers to detect this glider. In reaction, Russia tested an anti-satellite weapon able to shoot down US satellites.

However, countries competing for a great power status tend to overstate the importance of introducing hypersonic weapons into the arsenal. Military utility remains unknown in terms of defense and at strategic ranges, while hypersonic weapons appear to be primarily useful to "the aggressive and the disadvantaged". The Canadian government should work towards increasing the awareness and understanding of the hypersonic military capability. It should also promote controlling its spread through international arms control tools and contribute to NATO's goal to establish EDTs governance norms. In doing so, Canada could prevent further disconnection between technical experts on the one hand and political and military representatives, on the other hand. Canada can work with its allies to better regulate the development and use of hypersonic technology for military purposes.

Hypersonic gliders with strategic ranges are covered by the New START. Their proliferation is expected only among countries that already possess ballistic missiles, necessary for their booster phase. In contrast, the development of hypersonic cruise missiles is farther behind since hypersonic propulsion is costly in fuel and resources.

Canada should revisit hypersonic technology and missile exports to avoid the proliferation of offensive weapon systems. The Missile Technology Control Regime tends to be the focal forum to clarify and update the regulation as missile technology evolves, together with the Wassenaar Agreement on dual-use technology and the Hague Code of Conduct against ballistic missile proliferation. The debates are still ongoing on how these tools could restrict hypersonic gliders, building on the MARV analogy.

Canada and other countries willing to introduce reforms to global missile governance would also need to factor in the dual-use character of hypersonic technology. Especially hypersonic propulsion has an immense potential to help build a more sustainable infrastructure for space exploration. Controlling the weaponization of hypersonic technology should not prevent further development of space aircraft which can also glide at hypersonic speeds (albeit without an attached warhead).