THE POTENTIAL OF HYPERSONIC WEAPONS AND THE GREAT MILITARY POWERS STRATEGY REGARDING THEIR PRODUCTION – CASE STUDY –

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Hypersonic missiles are a new category of weapons that have sparked intense debate among security experts. The hypersonic weapons, this combination of speed, accuracy, surprise, and maneuverability makes the defense against them more difficult than against standard ballistic or cruise missiles and therefore makes them more destabilizing. Capable of traveling over five times the speed of sound (Mach 5), and of performing evasive maneuvers mid-flight, they are considered practically impossible to intercept using conventional missile defense systems.

Innovative nuclear and conventional weapon delivery systems are impressive and developing. These are grouped into three categories: intercontinental ballistic missiles, hypersonic delivery systems and new advanced strategic weapon delivery capabilities. These and other technological advances being made simultaneously may also impact arms control and strategic stability.

Other characteristics of hypersonic systems, however, are potentially advantageous compared with ballistic missiles. Of particular interest are the ability to fly at low altitude, making detection by earth-based sensors difficult; the ability to maneuver during flight to avoid detection and interception; and the unpredictability of targets, since hypersonic vehicles do not follow a ballistic trajectory.

Keywords: hypersonic weapons; hypersonic cruise missiles; hypersonic glide vehicles; capacity of maneuver; missile-defense;

PRELIMINARY CONSIDERATIONS

The renewal of *super power* status competition has led to the prioritizing in defense planning of the great powers on the capabilities for conducting so-called high-*end conventional warfare*, meaning large-scale war, high-intensity, technologically sophisticated conventional warfare against adversaries with similarly sophisticated military capabilities.

Weapon acquisition programs that can be linked to preparing for high-end warfare include (to mention only a few examples) those for procuring advanced aircraft and the next-generation long-range bomber, highly capable warships (attack submarines and destroyer), ballistic missile defense capabilities, longer-ranged land-attack and anti-ship weapons, new types of weapons such as lasers, and hypervelocity projectiles, new intelligence, surveillance, and reconnaissance capabilities, military space capabilities, electronic warfare capabilities, military cyber capabilities, hypersonic weapons, and the military uses of robotics and autonomous unmanned vehicles, quantum technology, and artificial intelligence.

The challenges generated by emerging and disruptive technologies in the arms realm can be represented by five significant and potentially disruptive technological developments: hypersonic weapons, missile defense, artificial intelligence and automation, counterspace capabilities and computer network operations (cyber). This article will highlight only details specific to hypersonic weapons.

One of the highlights of Russian President Vladimir Putin's March 2018 State of the Nation address was the presentation of two new nuclear delivery systems, which, he claimed, could evade US anti-ballistic missile defenses. Even seasoned security experts were not immune to this hype. Since then, hypersonic weapons have received considerable attention, grabbing the headlines, and generating considerable hype. Some have argued that hypersonic weapons will ignite a new arms race that promises to upend traditional strategic stability calculations (Smith, 2019). Hypersonic speeds are typically speeds that are at least five times greater than the speed of sound, or Mach 5 or 6,174 kilometers per hour. Ernst Mach was a late 19th century physicist who studied gas dynamics. The speed of sound varies depending on the temperature of the air through which the sound moves. At sea level and an air temperature of 15 degrees Celsius (59 degrees Fahrenheit) the speed of sound is 1,225 km/h.

A hypersonic missile is a weapon that can travel at speeds above Mach 5 (five times the speed_of sound, or 6,174 kilometers per hour) while carrying a warhead that can be maneuvered during flight, and be terminally guided towards its target. Unlike ballistic missiles, which follow a parabolic trajectory, hypersonic weapons glide or fly at a relatively constant height, which has the potential to reduce warning times and make them harder to detect. Details are presented in *figure no.1*.

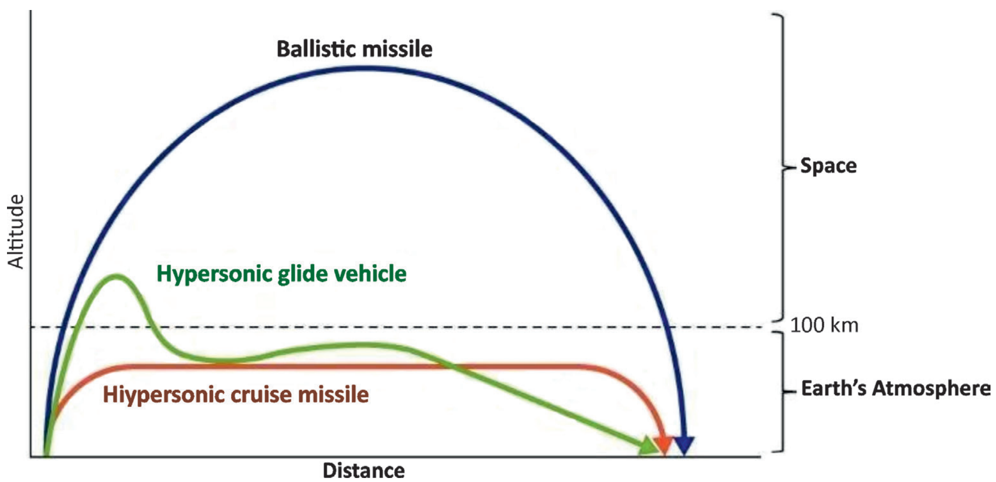

Figure no. 1: *Hypersonic technique vs. Traditional ballistic missiles and cruise*
(Kunertova, 2021, p. 5)

In theory, this combination of speed, accuracy, surprise and maneuverability makes hypersonic weapons more difficult to defend against than standard ballistic or cruise missiles, and therefore makes them more destabilizing. However, the reality is more nuanced: *"Their speed, accuracy, maneuverability, and unusual altitude can decrease warning and decision time, and increase the ability to strike nuclear-related targets with conventional weapons"*, said Kingston Reif, the director for disarmament and threat reduction policy at the Arms Control Association. (Mackinnon, 2019).

As part of the renewed emphasis on capabilities for high-end conventional warfare, DoD officials have expressed concern that US superiority in conventional weapon technologies has narrowed or in some cases even been eliminated by China and (in certain areas) Russia. In response, DoD has taken a number of actions

in recent years that are intended to help maintain or regain US superiority in conventional weapon technologies, including increased research and development funding for new militarily applicable technologies such as artificial intelligence, autonomous unmanned weapons, hypersonic weapons, directed-energy weapons, biotechnology, and quantum technology. In addition to the above-mentioned efforts for maintaining US superiority in conventional weapon technologies, DoD is placing new emphasis on innovation and speed in weapon system development and deployment, so as to more quickly and effectively transition new weapon technologies into fielded systems.

The 2018 National Defense Strategy (NDS) places states deliver performance at the speed of relevance. Success no longer goes to the country that develops a new technology first, but rather to the one that better integrates it and adapts its way of fighting. *"Current processes are not responsive to need; the DoD is over optimized for exceptional performance at the expense of providing timely decisions, policies, and capabilities to the warfighter. Our response will be to prioritize speed of delivery, continuous adaptation, and frequent modular upgrades. We must not accept cumbersome approval chains, wasteful applications of resources in uncompetitive space, or overly risk-averse thinking that impedes change. Delivering performance means we will shed outdated management practices and structures while integrating insights from business innovation."* (Department of Defense, 2018, p. 10). DoD has taken steps to accelerate weapon system development, and decision-making authority has been delegated to the military services. (Government Accountability Office, 2020).

Many weapons can be employed for offensive and defensive purposes, but hypersonic weapons, especially those designed for use in a regional context, are primarily intended to be used offensively, to destroy high-value enemy assets, including command-and-control facilities. This raises two major concerns: the risk of rapid escalation from a minor crisis to a full-blown war and the unintended escalation from conventional to nuclear warfare.

Hypersonic boost glide weapons function by using a multi-stage ballistic missile as the boost phase, throwing a vehicle into near earth orbit, which then descends and begins gliding at hypersonic speeds along the edge of the atmosphere. As the vehicle descends back to earth, it pulls upwards, and begins skimming the atmosphere in a *"glide"* phase, before diving downwards onto its target at the terminal phase.

THE SITUATION ON THE EVOLUTION OF SUPERSONIC WEAPONS

Since nations first went to war, speed has been a key factor in combat, particularly at the very onset of battle. The rapid concentration and employment of force can help a belligerent overpower an opponent and avoid a costly war of attrition, an approach that underlaid Germany's *blitzkrieg* (lightning war) strategy during World War II and America's *"shock and awe"* campaign against Iraq in 2003. (Klare, 2019). Today, speed will alter the calculus of combat and deterrence even further with the imminent deployment of hypersonic weapons. With the time between launch and arrival on target dwindling to 10 minutes or less, the introduction of these weapons will introduce new and potent threats to global nuclear stability.

Hypersonic weapons are said by proponents to be especially useful at the onset of battle, when they can attack an opponent's high-value targets, including air defense radars, fighter bases, missile batteries, and command-and-control facilities. The incapacitation of those facilities at an early stage in the conflict could help smooth the way for follow-on attacks by regular air, sea, and ground forces. Yet, as the same facilities are often tied into a nuclear-armed country's nuclear warning and command systems, attacks against them could be interpreted by the target state as the prelude to a disarming first strike and trigger the early use of its own nuclear weapons. (Ibid). Several countries are developing hypersonic weapons, which fly at speeds of at least Mach 5 (five times the speed of sound). (Speier, 2017, pp. 53-93). There are two primary categories of hypersonic weapons:

- *Hypersonic glide vehicles* (HGV) are launched from a rocket before gliding to a target;
- *Hypersonic cruise missiles* (HCM) are powered by high-speed, air-breathing engines, or *"scramjets"*, after acquiring their target.

The main difference between the two is that the hypersonic cruise missile is propelled throughout the flight by an air-jet (scramjet) while the glide vehicles are a hybrid: are accelerated at hypersonic speeds using a rocket engine – booster to a predetermined altitude after which the glider is separated and glides to the target being able to *maneuver as* a reentry vehicle specific intercontinental ballistic missiles (ICBMs) cannot do.

So, in the first stage we have a propelled flight to a predetermined altitude (about *19 – 20 km),* then the glider separates, reduces altitude and maneuvers up to the target. Obviously, the more it maneuvers, the more loose speed. Details regarding the operation of a hypersonic cruise missile are presented in *figure no.2.*

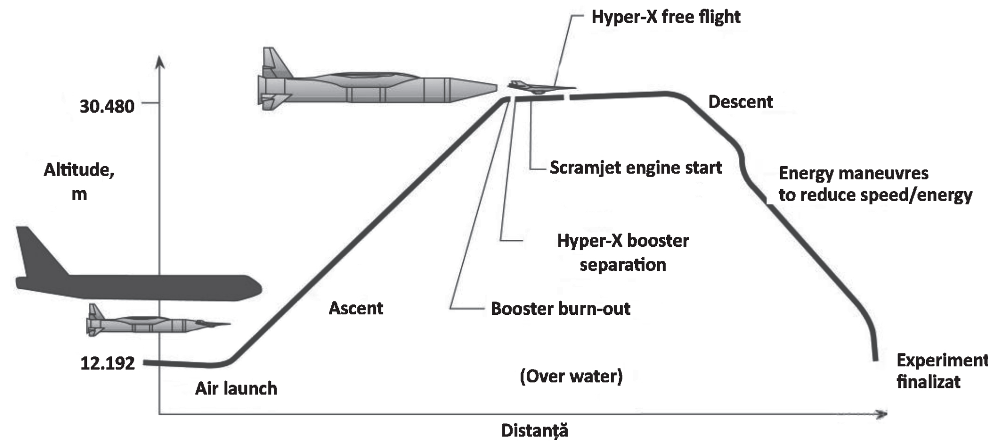

Figure no. 2: Stages of starting a scramjet
(NASA, p. 2)

Clearly, the glide vehicle is a shortcut in obtaining the hypersonic weapon, and although it shows certain advantages in front of a classical ballistic missile, it is far from the challenges and benefits provided by a cruise missile capable of supporting the hypersonic speed throughout the flight. We have an object flying through the atmosphere (under 90 km altitude, probably somewhere between 20 and 30 km altitude) over long distances (1000 – 2000 km) permanently propelled by an aero reactor engine - scramjet and which must also be able to maneuver.

Unlike ballistic missiles, hypersonic weapons do not follow a ballistic trajectory and can maneuver in route to their destination. Hypersonic weapons could enable *"responsive, long-range, strike options against distant, defended, and/or time-critical threats (such as road-mobile missiles) when other forces are unavailable, denied access, or not preferred".* (US Congress, 2019, p. 16). Conventional hypersonic weapons use only kinetic energy – energy derived from motion – to destroy unhardened targets or, potentially, underground facilities. (Speier, 2021, p. 13).

Hypersonic weapons could challenge detection and defense due to their speed, maneuverability, and low altitude of flight. (Department of Defense, 2019, pp. 2-10). For example, terrestrial-based radar cannot detect hypersonic weapons until late in the weapon's flight. (Speier, 2019, pp. 9,11). This delayed detection compresses the timeline for decision makers assessing their response options and for a defensive system to intercept the attacking weapon – potentially permitting only a single intercept attempt. (Acton, 2021).

Some analysts have suggested that space – based sensor layers – integrated with tracking and fire-control systems to direct high-performance interceptors or directed energy weapons – could theoretically present viable options for defending against hypersonic weapons in the future. Indeed, the 2019 Missile Defense Review notes that *"such sensors take advantage of the large area viewable from space for improved tracking and potentially targeting of advanced threats, including HGVs and hypersonic cruise missiles."* (Department of Defense, 2019, pp. 6, 30). Those who support these development efforts argue that hypersonic weapons could enhance deterrence, as well as provide the U.S. military with an ability to defeat capabilities such as advanced air and missile defense systems that form the foundation of U.S. competitors' anti-access/area denial strategies. (Zakheim, 2019, p.2). The NDS 2018 identifies hypersonic weapons as one of the key technologies *"(ensuring the United States) will be able to fight and win the wars of the future."* (Department of Defense, 2018, p. 3).

Unlike programs in China and Russia, US hypersonic weapons are to be conventionally armed. As a result, US hypersonic weapons will likely require greater accuracy and will be more technically challenging to develop than nuclear-armed Chinese and Russian systems. Indeed, according to one expert, *"a nuclear-armed glider would be effective if it were 10 or even 100 times less accurate (than a conventionally-armed glider)"* due to nuclear blast effects. (Acton, 2017, pp. 161, 165). According to open-sources reporting, the United States has a number of major offensive hypersonic weapons and hypersonic technology programs in development. DoD is also investing in counter-hypersonic weapons capabilities.

Although the United States, Russia, and China possess the most advanced hypersonic weapons programs, a number of other countries – including Australia, India, France, Germany, and Japan – are also developing hypersonic weapons technology. Since 2007, the United States has collaborated with Australia on the Hypersonic International Flight Research Experimentation program to develop hypersonic technologies. The most recent test, successfully conducted in July 2017, explored the flight dynamics of a Mach 8 hypersonic glide vehicle. India has similarly collaborated with Russia on the development a Mach 7 hypersonic cruise missile. France also has collaborated and contracted with Russia on the development of hypersonic technology. Germany successfully tested an experimental hypersonic glide vehicle in 2012; however, reports indicate that Germany may have pulled funding for the program. Finally, Japan is developing the hypersonic cruise missile

and the hyper velocity gliding projectile. Other countries – including Iran, Israel, and South Korea – have conducted foundational research on hypersonic airflows and propulsion systems, but may not be pursuing a hypersonic weapons capability at this time. (Speier, 2018). *"As the Pentagon looks to catch up with China and Russia* in the *hypersonic arms race, there is a widespread acknowledgement that the technology to defend against weapons capable of reaching Mach 5 or higher simply isn't there"*. (Mehta, 2019). This, some analysts argue, is because US competitors such as China and Russia already possess the ability to strike the United States with intercontinental ballistic missiles, which, when launched in salvos, could overwhelm US missile defenses. (Axe, 2019, p. 14). Furthermore, these analysts note that in the case of hypersonic weapons, traditional principles of deterrence hold: *"it is really a stretch to try to imagine any regime in the world that would be so suicidal that it would even think threatening to use – not to mention to actually use – hypersonic weapons against the United States ... would end well."* (Raitasalo, 2019).

CAPABILITIES AND CHARACTERISTICS

Hypersonic missiles (HMs) represent a new category of weapons. The term *hypersonic* refers to missiles, rockets, air, and spacecraft that can reach speeds within the atmosphere greater than Mach 5, i.e., greater than 6174 km/h (actual Mach 5 speeds can vary depending on the altitude, local weather conditions, and temperature). HMs could be launched from a variety of air, sea, or land platforms. Even though they can travel at higher speeds than HMs and thus can reach a target quicker, traditional ballistic missiles such as intercontinental ballistic missiles (ICBMs) – and their payloads – are not commonly classified as hypersonic weapons because they have little to no ability to maneuver. What sets HMs apart from traditional types of ballistic missiles and makes them strategically significant is that they offer a combination of speed, range, maneuverability, and precision accuracy. In comparison to current military systems, HMs would enable military operations from longer ranges with shorter response times and greater effectiveness.

Developing these systems were extremely complex and expensive endeavors of which few nations were capable. Developing hypersonic flight systems capable of sustained flight, such as HGVs or HCMs, is even more difficult. Both of these types of systems will be designed for one-time uses. This makes them stepping stones to the more challenging designs of reusable systems that have longer flight times and much longer operational lives. After many years of concentrated effort and investment, the United States, Russia, and China may be closing in on these one-time-use, expendable capabilities. Importantly, maneuverability also delivers a significant capability to elude missile defense systems.

In stark contrast, soon after separation from the still-rising ballistic missile at altitudes ranging from 42 km to over 105 km the HGV reenters the atmosphere and can maneuver to glide along the upper atmosphere or change direction and race through the atmosphere for hundreds or possibly thousands of miles before homing in on its target. HGVs combine the best features of ballistic missiles and cruise missiles: the greater Mach 5 speeds and range of the former together with the maneuverability and accuracy of the latter.

To illustrate, the mainstay of the U.S. land-based nuclear deterrent, the Minuteman III ICBM, has an accuracy – i.e., circular error probable (CEP) in Department of Defense (DOD) parlance – of approximately 120 meters which signifies that half the reentry vehicle in atmosphere (RVs) launched are projected to strike within 120 meters of their intended targets; its range is 12,997 km (Missile Defense Project, 2018) and travels at speeds approaching 24,135 km/h. On the other hand, the Tomahawk, the most advanced cruise missile in the US inventory, has a CEP of 10 meters giving it far greater accuracy than the Minuteman III, but flies at subsonic speeds (defined as between 563 and 1,207 km/h) with a range of only 1,667 km. (Missile Defense Project, 2018). In sum, HGVs offer unique features to military planners: speeds unmatched by other kinetic weapons apart from ballistic missiles; potentially longer ranges than ballistic missiles; greater payload capability over a given range; midcourse maneuvering; low-altitude flight; and great accuracy.

Hypersonic cruise missiles would fly many times faster but be equally as accurate as today's air-, sea-, or land-launched cruise missiles. Unlike hypersonic glide vehicles, however, HCMs are powered throughout their full flight, staying aloft by aerodynamic lift like an airplane. For example, HCMs achieve hypersonic speeds by a rocket but then change over to an internal scramjet (supersonic combustion ramjet engine) flying thereafter on their own power. When HCMs become operational, their speed and maneuverability will make them extremely difficult to interdict even though they fly within the altitude range of current air defenses. (Freedberg, 2018). In addition, HMs could be reconfigured to be outfitted with sensors and communication equipment to act as an intelligence, surveillance, and reconnaissance (ISR) platform. Travelling at Mach 5 speeds, a hypersonic ISR platform could in some cases reach and overfly an area of interest, with a high level of survivability, faster than repositioning an ISR satellite.

There are some hypersonic system and technology challenges. Several technological obstacles must be addressed before a viable HGV capability can be realized. This includes ensuring that the structural integrity of the hypersonic vehicle remains intact and the onboard instrumentation and payload continue to function properly. Specifically, this includes the need to: manage the extreme heat generated during hypersonic flight within the atmosphere which could peel off an HGV's protective coatings and destroy onboard electronics; develop guidance systems that can deliver sufficient accuracy during maneuvering hypersonic flight; and, withstand the enormous aerodynamic forces buffeting the vehicle during flight. Additional wind-tunnel facilities to test HMs in simulated flight must also be built. (Wilson, 2019). The development of scramjet engines for HCMs present particular challenges. A scramjet must function at speeds that would rip standard jet engines apart. The US Air Force has developed a scramjet engine that was flight tested four times between 2010 and 2013. These tests validated the feasibility of a scramjet-powered vehicle for weapon applications but more development needs to be undertaken.

According to Dr Thomas Bussing, Vice President of Advanced Missile Systems at Raytheon, a leader in the development of hypersonic systems, over the past decade significant progress has been made to surmount some of these technical challenges including advances in computational fluid dynamics, new materials and electronics, and guidance systems better able to endure the harsh environment of hypersonic flight. (The Economist, 2019). To underscore this fact, the United States, China, and Russia are expected to deploy operational HMs soon. In fact, Russia claims it has already fielded a hypersonic missile system. An HM capability is viewed by US defense officials as the means to project power and counter the multi-layered anti-access/area-denial networks deployed by China, Russia, and increasingly by Iran. HMs would enhance U.S. power projection enabling the capability to attack high-value targets at the beginning of a conflict and throughout its duration. Apart from the activities of the three nations surveyed above, other nations including Australia, France, Germany, India and Japan have conducted some HGV research. Iran, Israel, and South Korea have conducted basic research on hypersonic aerodynamics and propulsion systems but do not appear currently to be pursuing a hypersonic weapon capability.

For example, as noted earlier, an HGV spends little time in space, rather the bulk of its journey is flown on a depressed and unpredictable trajectory within the atmosphere meaning its intended target and the path it will follow getting to it would remain largely unknown. This contrasts with the predictable, parabolic trajectories in space that traditional ballistic missiles and their RVs follow which can be calculated soon after launch and hence tracked and targeted. The optimum approach to boost-phase intercept is a network of space-based interceptors which would provide significantly increased defense coverage and HGV intercept capabilities.

How Scramjets Work: a ramjet operates by combustion of fuel in a stream of air compressed by the forward speed of the aircraft itself, as opposed to a normal jet engine, in which the compressor section (the fan blades) compresses the air. The air flow through a ramjet engine is subsonic, or less than the speed of sound. Ramjet-propelled vehicles operate from about Mach 3 to Mach 6. A scramjet supersonic-combustion ramjet) is a ramjet engine (a type of jet engine in which the air drawn in for combustion is compressed solely by the forward motion of the aircraft) in which the airflow through the engine remains supersonic, or greater than the speed of sound. Scramjet powered vehicles are envisioned to operate at speeds up to at least Mach 15. Ground tests of scramjet combustors have shown this potential. (National Aeronautics and Space Administration, 2006, p. 4).

The United States, China, and Russia are developing hypersonic missiles that will become increasingly important components of their arsenals in the coming decade. The speed (greater than Mach 5 or ~6174 km/h), maneuverability, and accuracy of HMs, couple d with the impediments to detect and track them, will provide unique strategic and tactical advantages: increased targeting options including more accurate and much speedier interdiction of time-sensitive and mobile targets; greatly reduced adversary decision-making time; difficulty to defend against; can carry both conventional and nuclear payloads; and, could be utilized in a reconnaissance/surveillance configuration.

Technological hurdles that must be surmounted before operational hypersonic missiles can be fielded include: managing the intense heat produced in hypersonic flight which could erode the vehicle's protective coating and destroy onboard electronics; developing guidance systems that deliver needed accuracy and ability to withstand the aerodynamic forces pounding the vehicle during hypersonic flight; completing development of scramjet engines and other technologies needed to field an operational hypersonic cruise missile; and, constructing the requisite infrastructure such as wind-tunnel facilities to test hypersonic missiles in speed more than Mach 5 simulated conditions.

Hypersonics are a potentially game-changing military technology. The United States, China, and Russia are at the forefront of the development of hypersonic missiles. Offensive hypersonic missiles, when fully integrated into weapon arsenals and linked with command and control, communications and ISR networks, will give the nations possessing them distinct strategic and tactical advantages by providing more and faster targeting options on a global scale. A wider array of targeting options will enable HM strikes against time-sensitive and moving targets previously not achievable because of the time it took a missile to arrive there. Hypersonic missiles can also generate dislocating effects on an adversary by collapsing the *"decision space"* thereby reducing his time to make necessary decisions. Moreover, HMs will pose considerable difficulties for missile defenses because of their unique features including speed, ability to maneuver, and unpredictability. HMs will substantially reduce the time available to detect, assess, track, and engage the incoming missile. Improved missile defenses will therefore be needed to address the HM threat.

This would include upgrades to current defenses and the development of new systems such as a space – sensor layer to detect/track HMs and cue interceptors, as well as boost-phase intercept capabilities to destroy HMs before their hypersonic payloads are released. The fact that China and Russia are expected to field operational HMs shortly – Russia claims it has already done so – and that they are most likely to carry nuclear payloads, requires that defense against the hypersonic threat becomes a US national priority. (IFPA National Security Update, 2019, p. 3).

CONCLUSIONS

The world would be safer if the proliferation of hypersonic missiles was strongly hindered. Such missiles are a new class of threat because they are capable both of maneuvering and of flying faster than 5,000 km/hr. These features enable such missiles to penetrate most missile defenses and to further compress the timelines for response by a nation under attack. The proliferation of such missiles beyond the United States, Russia, and China could result in other powers compressing their response timelines in ways that set their strategic forces on hair-trigger states of readiness – such as a strategy of *"launch on warning"*. And such proliferation could enable such states to more credibly threaten attacks on major powers.

Each of these countries initiated its pursuit of hypersonic weapons for unique strategic purposes, but all seem to have recently accelerated their efforts partly to overtake progress made by their rivals – behavior that has all the earmarks of a classic arms race. That hypersonic weapons are being designed for offensive use at an early stage in a conflict has been evident in US strategic policy from the beginning.

The persistent high speed and long atmospheric flight time of hypersonic vehicles result in an extremely severe operating environment requiring advanced new systems, components, materials, design tools, and test facilities.

Hypersonic missiles can be viable threats for as long as the main technological challenges specific to the hypersonic propelled flight find itself solutions. There are offensive weapons, designed to compress the time to the target and decrease the reaction capacity of the enemy concerned. There is already information on the development of capable radars for detecting and tracking them (despite the shielding plasma cloud) and will probably be seen soon and specially configured satellite networks for this purpose, being targeted long-range missiles.

Plans for hypersonic weapons programs, it might consider a number of questions about the rationale for hypersonic weapons, their expected costs, and their implications for strategic stability and arms control. Some military leaders expressed concerns, noting in their explanatory statement that the rapid growth in hypersonic research has the potential to result in stove-piped, proprietary systems that duplicate capabilities and increase costs.

Regarding strategic stability, analysts disagree about the strategic implications of hypersonic weapons. Have identified two factors that could hold significant implications for strategic stability: the weapon's short time-of-flight – which, in turn, compresses the timeline for response – and its unpredictable flight path – which could generate uncertainty about the weapon's intended target and therefore heighten the risk of miscalculation or unintended escalation in the event of a conflict. It can be considered that unintended escalation could occur as a result of warhead ambiguity, or from the inability to distinguish between a conventionally armed hypersonic weapon and a nuclear-armed one.

However, certain analysts claim that, even if a State did know that an HGV launched toward it was conventionally armed, it may still view such a weapon as strategic in nature, regardless of how it was perceived by the state firing the weapon, and decide that a strategic response was warranted. Differences in threat perception and escalation ladders could thus result in unintended escalation and the second the strategic implications of hypersonic weapons are minimal and don't change much in terms of strategic balance and military capabilities.

The New START Treaty, a strategic offensive arms treaty between the United States and Russia, does not currently cover weapons that fly on a ballistic trajectory

for less than 50% of their flight, as do hypersonic glide vehicles and hypersonic cruise missiles.

All three major powers have explored similar applications of hypersonic technologies, but their strategic calculations in doing so appear to vary, with the United States primarily seeking weapons for use in a regional, non-nuclear conflict and Russia emphasising the use of hypersonic weapons for both conventional and nuclear applications. Whatever the case, the speed of attack largely accounts for the growing pursuit of hypersonic weaponry, along with their extensive maneuverability and perceived invulnerability to existing defensive systems.

As an alternative, it is possible to negotiate a new international arms control agreement that would institute a moratorium or ban on hypersonic weapons tests. This would assume that the prohibition of tests would be a *"very verifiable"* and *"very efficient"* means of preventing a potential arms race and preserving strategic stability. It can also be considered that a test ban would be infeasible, as no clear technical distinction can be made between hypersonic missiles and other conventional capabilities that are less prompt, have shorter ranges, and also have the potential to undermine nuclear deterrence.

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