Defence Research Paper

Tipping the Scales? The Influence of Hypersonic Weapons on the Military Balance between NATO and Russia

By Wing Commander Matthew Smith

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Abstract: The development of hypersonic weapons and their introduction into an increasingly competitive multipolar world order has generated much debate around their potential implications for stability. This research paper adds to the debate by examining how the introduction of hypersonic weapons may impact the future military relationship between NATO and Russia through the lens of offence-defence balance theory. It is contended that these weapons will not fundamentally alter the military balance between NATO and Russia, their offensive use being constrained by their potential to escalate conflict into the nuclear domain. Hypersonic weapons will increase the salience of nuclear weapons and missile defences within the relationship which may have more serious consequences for stability in the future. The fear of what hypersonic weapons might achieve, rather than their objective utility, is driving a cycle of action and reaction, but opportunities exist for these fears to be ameliorated without either side having their security materially undermined.

Introduction

The unipolar world order that characterised the post-Cold War period is now giving way to an era of renewed great power competition, with Western hegemony now being challenged by the rising power of China and an increasingly assertive Russia. This multipolar competitive dynamic is strongly influencing the security agendas of the US, Russia, and China.[1] Into this climate of great power competition will be introduced the newest evolution of missile technology. Hypersonic weapons promise the ability to deliver nuclear or conventional effects at tremendous speeds and at significant ranges, presenting the potential to penetrate even the most advanced defences.[2] The required technology to enable these capabilities has presented huge research and development challenges that have taken decades to overcome. However, the US, Russia, and China now stand on the verge of mastering the technology and introducing viable hypersonic weapons systems into their arsenals.[3]

There is a lack of consensus amongst the growing body of literature relating to hypersonic weapons as to what implications these weapons will have for the future security environment. Some claim that the influence of hypersonic weapons has been greatly overstated.[4] Others contend that hypersonic weapons are 'game changers' that will fundamentally alter the future battlespace.[5] Analysts have highlighted the need to carefully evaluate the implications to offence and defence and to determine how much of an advantage these systems might actually offer.[6] This paper aims to add to this body of analysis by assessing the impact that these weapons will have on the stability of the military relationship between NATO and Russia through the lens of offence-defence balance theory, as proposed by Robert Jervis in his paper 'Cooperation under the Security Dilemma.'[7] The paper will focus on the NATO-Russia relationship rather than other actors, notably that formed by China and the US, for three reasons. First, examining one dyad will allow a more detailed exploration of the relationship, thus offering more valid results than a broader and shallower approach would offer. Second, there are only two salient dyads and so even examining both would not necessarily enhance the generalisability of findings. Finally, the NATO-Russia relationship is perhaps the most volatile and, therefore, there is perhaps a more pressing need to examine the impact of hypersonic weapons on this dyad.

The paper will advance in three phases. First, the theoretical framework of the offence-defence balance will be set out; the strengths and limitations of the theory will be explored and its relevance to examining how hypersonic weapons will impact the NATO-Russia relationship will be established. Second, to understand how these weapons may influence offensive or defensive postures, the defining characteristics of hypersonic weapons will be assessed. This review will include analysis of the key technology variations and the military benefits and challenges associated with each. The concepts explored in sections 1 and 2 will then be applied in an exploration of what impact the introduction of hypersonic weapons will have on the NATO-Russia military relationship using offence-defence theory. Through this analysis it will be contended that hypersonic weapons will not destabilise the offence-defence balance

that exists between NATO and Russia. The use of hypersonic weapons will be significantly constrained by the risks of escalation that exist in a peer-to-peer nuclear power context, which will encourage prudence rather than aggression. However, their introduction will likely increase the salience of nuclear deterrence and missile defences within the relationship; this may have implications for stability in the future that would benefit from further analysis. Perceptions of what hypersonic weapons could achieve, rather than their objective utility in a peer context, is driving a cycle of action and reaction. Therefore, grasping any opportunity to positively influence perceptions is likely to be benefit both parties without materially undermining the security of either.

Offence-Defence Theory

This section will explore offence-defence theory, seeking to establish its theoretical underpinnings, its limitations, and how it is intended to be operationalised for this study. Offence-defence balance theory is grounded in the structural-realist ontology which contends that the anarchical structure of the international system leads to a system of self-help whereby states are compelled to maximise their own security.[8] Offence-defence theories' central proposition is that if it is easier to conduct offensive operations than it is to mount a defence, then conflict is more likely. Hence, when the balance lies with the offence, a system will tend towards instability. Conversely, where the advantage rests with defence, the likelihood of conflict decreases, and stability is likely to ensue.[9] The instability arising from a situation where offence has the advantage accords with definitions of nuclear instability that posit that states may be incentivised to strike first where it is perceived that to not do so would be to risk suffering a disarming first strike by an adversary.[10]

The theory offers opportunities to expand the generally pessimistic realist paradigm by offering a mechanism to explain conditions under which cooperation is possible. The theory has been used to attempt to explain the conditions under which arms control may be possible, the likelihood of conflict, optimising military postures, and explaining the role of various factors on stability, depending on the variant of the theory being used.[11] The general theoretical construct would, therefore, seem to offer utility in framing a study of the impact that new technologies may have on stability. Several variations of offence-defence theory have been put forward, with a key difference being the scope of variables included in the analysis of what impacts the balance. The most parsimonious versions of the theory privilege the role of geography and technology, whilst broader versions include wider sets of military factors, consideration of social and political order, and diplomatic factors.[12]

Like all theories, offence-defence theory is subject to challenge and criticism. The issue of identifying whether postures or specific technologies can be classified as either defensive or offensive is often raised as a concern.[13] Booth and Wheeler contend that establishing intent constitutes an 'unresolvable uncertainty'.[14] Jervis is more optimistic, contending that whilst ambiguity will often abound, in some cases, a defensive posture will be clearly distinguishable from an offensive one.[15] Lieber argues that scholars have overstated the extent to which

technology influences battlefield outcomes and 'the influence that beliefs of offense or defense dominance have on political or strategic behaviour'.[16] Other criticisms surround the validity of the broad theoretical variations, in that they lose parsimony and include variables that the theory should seek to explain.[17] In addition to these issues, Lynn-Jones notes that further criticisms arise from failures of actors to correctly perceive the offence-defence balance, that there are other more prominent explanatory factors behind the causes of conflict, and that the usefulness of the theory is undermined by the balance always favouring defence and that states will manipulate the balance to their own advantage.[18] Whilst some of these issues may impact on the research, no theoretical model is likely to adequately explain all variables that will feed in to the stability of the dyad. A theoretical variant that best allows the management of these issues will, therefore, be utilised.

In recognition of some of the theoretical limitations outlined above, and given the research is intended to identify the impact of emerging hypersonic weapons, a theoretical approach that allows clear analysis of the role military technology plays in international relations is likely to be more valid. Thus, the most parsimonious version of the theory will be utilised, privileging the role that technology will play in adjusting the balance. Jervis's version of offence-defence theory allows such an approach to be taken whilst also accounting for the difficulty in determining intent, a key issue raised by critics of the theory. Adopting his variant will also allow any potential adjustment to be visually demonstrated on his Four Worlds model, as shown in Figure 1, below. The analysis will open with an initial appraisal of the general geo-strategic context of the NATO-Russia dyad before analysing the current balance of conventional and nuclear forces, situating the result within the Four Worlds model. Having established a baseline, the analysis will then seek to understand how and why hypersonic weapons might shift the balance and, hence, offer insight into their potential impact on stability within the dyad.

	OFFENSE HAS THE ADVANTAGE	DEFENSE HAS THE ADVANTAGE
OFFENSIVE POSTURE NOT DISTINGUISHABLE FROM DEFENSIVE ONE	**1** Doubly dangerous	**2** Security dilemma, but security requirements may be compatible.
OFFENSIVE POSTURE DISTINGUISHABLE FROM DEFENSIVE ONE	**3** No security dilemma, but aggression possible. Status-quo states can follow different policy than aggressors. Warning given.	**4** Doubly stable

Figure 1: Jervis's Four Worlds Model[19]

Hypersonic Weapon Characteristics

As hypersonic missiles are an emerging technology with development progressing at pace, it is important to define what constitutes a hypersonic weapon system and what advantages and disadvantages they may engender. This section will briefly examine what defines a hypersonic

weapon and discuss the two broad categories into which they fall. The military advantages afforded by hypersonic weapons will then be discussed before concluding with a precis of some of the operational challenges that they present. The term 'hypersonic' is generally accepted to refer to an object moving at or above five times the speed of sound (Mach 5).[20] However, a hypersonic weapon appears to be defined by more than just its speed. Other defining characteristics include the ability to manoeuvre through flight and to follow non-ballistic trajectories for most of their flight profile.[21] There are two broad vehicle categories that exhibit these characteristics: hypersonic glide vehicles (HGVs) and hypersonic cruise missiles (HCMs). Both have their own defining characteristics and associated advantages and disadvantages.

HGVs are typically accelerated out of the earth's atmosphere on a rocket system before detaching from their booster to re-enter the atmosphere. As they re-enter, control surfaces are employed to glide the vehicle through the atmosphere at hypersonic speed over extended ranges. The boost-glide profile of HGVs allows ranges comparable to intercontinental ballistic missiles (ICBMs) to be achieved but with a lower and more unpredictable trajectory.[22] Because they are harder to track than ICBMs after they have entered the glide phase and travel at significant speed, they greatly reduce the warning time available to adversaries.[23] In addition, their manoeuvrability improves their survivability compared to ballistic missiles by making them harder for missile defences to intercept. However, because they are unpowered, as energy is lost during the glide and through manoeuvring so will advantages in speed, and hence, surprise and survivability will be degraded.[24]

HGVs form the bulk of hypersonic weapons in development, with Russia having declared its Avangard strategic nuclear hypersonic capability operational in 2019.[25] Being a nuclear system, the challenges associated with achieving precise accuracy are less pronounced.[26] The United States is pursuing five different HGV options, although its accuracy requirements are more stringent than Russia's.[27] Having declared that it will not pursue nuclear armed hypersonic systems, the level of accuracy required for the Conventional Prompt Global Strike (CPGS) capability, and hence technological demands, are much greater. This goes some way to explaining why the US Navy, Army, Air Force and Defense Advanced Research Projects Agency (DARPA) HGV programmes remain some way off being fielded.[28] Other NATO nations are conducting hypersonic weapons research, including France, Germany, and the UK. However, their programmes are not as advanced and so it is likely that the US will be the first and, for a time, only operator of these systems within NATO.[29]

HCMs chiefly differ from HGVs in their propulsion, their flight profile, and the expected achievable range. HCMs are powered throughout their flight to target, generally by a supersonic combustion ramjet (scramjet). Scramjets require an initial rocket boost phase to create the conditions for it to operate under its own power.[30] HCMs will be able to manoeuvre as they transit within the earth's atmosphere, typically around Mach 5–7 and altitudes of 20–40km, before engaging their targets.[31] As with HGVs, HCMs greatly compress warning

times and present greater challenges for tracking and engaging than current ballistic or cruise missile technology. HCMs are unlikely to achieve the same ranges as HGVs, generally forecast at around 1,000km in comparison to over 5,500km for an HGV. The more stringent design requirements associated with achieving and sustaining engine combustion and enabling booster separation within the earth's atmosphere mean that they are likely to take longer to develop and enter service than HGVs.[32]

Figure 2 illustrates an overlay of the typical trajectories for HGVs and HCMs in comparison to that of an ICBM.

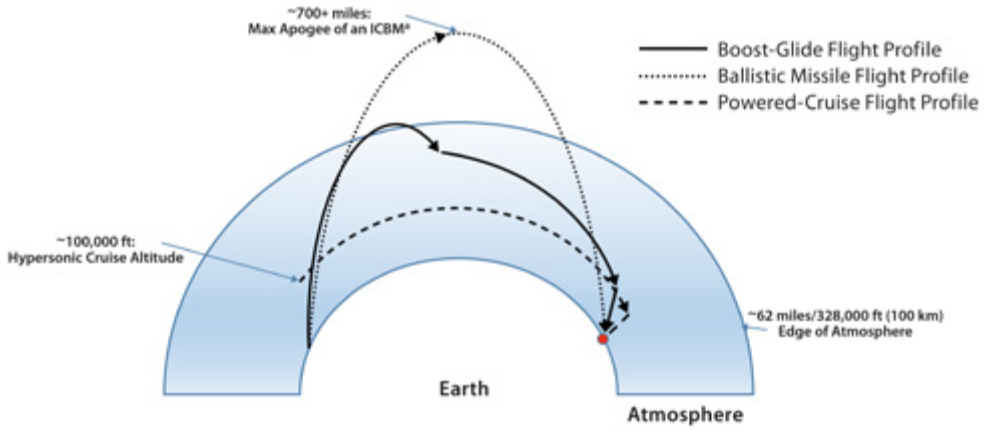

Figure 2: Illustrative Flight Profiles for Ballistic Missiles, HGV and HCM[33]

Russia is closest to fielding an operational HCM. The *Tsirkon* anti-ship HCM is claimed to have a range of around 1,000km and achieve speeds of over Mach 9, being launched from surface vessels and submarines, as well as potentially land-based launchers.[34] The weapon is presently in testing, although entry into service is not expected until after 2022.[35] The only current US HCM programme is the DARPA Hypersonic Air-breathing Weapons Concept (HAWC), aimed at enabling future HCM development, and hence, a US capability is not likely in the near future.[36] Other NATO partners are also developing HCM technology, notably France and Germany. However, their programmes are not as mature as HAWC.[37] The unique developmental challenges presented by HCMs has led to HGVs largely being the preferred route to hypersonic capability in the near term.[38] Whilst not classed as either an HGV or an HCM, the Russian *Kinzhal* air-launched ballistic missile is often considered as a hypersonic weapon, with its putative ability to achieve speeds of over Mach 10 and ranges of over 2,000km.[39] Given its characteristics and the potential threat it poses, it will be considered alongside HGVs and HCMs in this paper.

Hypersonic weapons offer notable potential advantages over other weapons systems. Their speed makes them extremely difficult to defeat with current missile defence technologies as well as offering the potential to prosecute fleeting targets of opportunity. Their speed will also reduce the reaction time of the enemy and thus better able them to

achieve surprise. Their manoeuvrability further adds to the difficulty for defences to track and engage them, increasing their potential to penetrate the most heavily defended targets. The range advantages that they enjoy over current cruise missiles offer greater stand-off range, a significant benefit if an adversary can deny access to an area of operations for launch platforms. These potential advantages have made them extremely attractive to military forces and have added to the perception of their great potential as offensive weapons.

The characteristics of hypersonic weapons that may offer offensive advantages also confer potential operational challenges, typically reduced to three key issues: warhead, target, and destination ambiguity.[40] Warhead ambiguity pertains to an actor being unable to determine whether a weapon being used against them is conventionally or nuclear armed. This issue specifically led to the cancellation of the US Conventional Trident Missile (CTM) owing to the risk of it being confused for a nuclear weapon and thus provoking a nuclear response.[41] This issue is not necessarily unique to hypersonic weapons, with many states, including Russia, already operating dual-capable missile systems.[42] Destination ambiguity relates to the challenge in discerning the target destination until very late in a flight profile of a weapon owing to the large cross-range capabilities that hypersonic weapons will likely possess.[43] Finally, target ambiguity arises when conventional and nuclear delivery or command-and-control related systems are commingled, and therefore, even if an actor is able to predict where a weapon is destined, it may not be able to determine what the intended target is.[44] Target ambiguity is, however, not uniquely related to hypersonic weapons, the same issue would present itself regardless of the weapon employed where different capabilities are collocated together. Nevertheless, all three of these issues could impact stability and must be carefully considered in any analysis of the impact of hypersonic weapons.

Hypersonic weapons, whether HGVs or HCMs, are perceived to offer opportunities to greatly improve the capabilities of forces that can overcome the technological challenges that have long stymied their realisation. However, the same characteristics that offer advantages also present operational challenges to their employment. The following sections will seek to operationalise offence-defence balance theory considering the advantages and challenges that have been discussed briefly here and that will be expounded upon in the analysis.

The Current NATO-Russia Balance

Having established the theoretical methodology and the characteristics of hypersonic weapons technology, these will all now be applied to an analysis of the current and potential future military balance between Russia and NATO. Recalling the analytical path discussed earlier, this study will first precis the geo-strategic context before providing an analysis of the current military balance, situating it within Jervis's Four Worlds model. The impact of hypersonic weapons on this balance will be assessed and thus the potential implications for stability can be determined.

The post-Cold War expansion of NATO into Russia's perceived sphere of influence led to the

buffer zone between Russia and its Western adversaries being substantially eroded; this is perceived by Russia to represent a substantial threat to its national security.[45] Thus, NATO's expansion, whilst undoubtedly welcomed by the acceding states who now benefit from the Alliance's protection, has potentially increased the military threat to which it is exposed. Although its strategic depth has been eroded, Russia does benefit from being able to mobilise its forces more rapidly in the event of a crisis, with NATO largely reliant on the mobilisation of forces from the US in a crisis.[46]

Tensions have increased significantly since the 2014 Ukraine Crisis, with both Russia and NATO nations instigating significant reforms and modernisation of their conventional and nuclear forces.[47] Additionally, Russia has bolstered military forces in its Western military district as well as in the Kaliningrad exclave and the Crimean Peninsula, furthering its ability to project power in the Baltic and Black Sea regions.[48] NATO has deployed forces to both the Baltic and Black Sea regions to assure alliance members and to demonstrate its resolve to resist any Russian aggression.[49] It is within this context of heightened military tensions that the balance of forces must be viewed and into which each will introduce hypersonic weapons with the intent of tilting the balance in their favour.

The balance of military power between NATO and Russia has been the subject of much academic scrutiny following the 2014 Ukraine Crisis. This section will draw on this literature to assess the present conventional and nuclear balance of military power. To situate the balance within Jervis's Four Worlds model, the analysis will first determine whether NATO and Russian military postures are distinguishable as being offensive or defensive. The analysis will continue with a review of whether offensive or defensive forces presently have the advantage. The assessment will chiefly focus on the balance in the Baltic and Black Sea regions as these are considered by NATO to be the most likely areas of military competition with Russia and, hence, have seen increased deployments of NATO forces under the Enhanced Forward Presence (EFP) initiative.[50]

Russia seeks to attain its national defence objectives through the strategic deterrent concept, leveraging all instruments of national power to improve its security.[51] The concept's purported defensive intent is argued to be undermined by internal policy contradictions which prescribe offensive or coercive approaches to achieving security, increasing the potential for its posture to be viewed as offensively orientated.[52] Russia's intent to threaten its adversaries with offensive action was highlighted by Russian Chief of the General Staff Gerasimov, who claimed that Russia must respond to Western threats by creating threats of its own.[53] NATO clearly perceives that Russia's posture is aggressive and underpins revanchist intent.[54] Thus, although Russia espouses a security strategy that is defensive in nature, its wider rhetoric and military activity has led its adversaries to struggle to discern anything other than aggressive intent.

General Gerasimov claims that NATO and the US seek to upset the status quo to their own benefit through offensive global action.[55] This is repeated in Russia's Security Strategy which

criticises the build-up of NATO's military capabilities, its endowment of global functions, and its violation of international law.[56] NATO's declared intent to focus primarily on collective defence thus lacks credibility with Russia who sees it as an offensively orientated organisation. This view has been exacerbated by NATO's expansion and the placement of ballistic missile defences (BMD) adjacent to Russian territory.[57] Thus, NATO claims to be a defensively orientated organisation, but this posture cannot be distinguished by its foremost adversary who sees it as an aggressor intent on upsetting the status quo. It is clear, therefore, that both Russia and NATO have adopted defensive postures, but these postures are read as offensive by the other.

Both NATO and Russia possess a wide spectrum of conventional capabilities that allow them to compete across the full range of conflict but whilst each holds advantage in some areas, neither holds an overall offensive advantage over the other's defensive capabilities. Russia is estimated to possess a preponderance of land power over NATO forces in the Baltic region, even when considering NATO's recently enhanced regional presence.[58] The NATO EFP forces are more a demonstration of alliance commitment to Baltic security and a deterrent to Russian aggression rather than a force designed to repel a Russian attack.[59] Given Russia's significant mechanised land force capabilities, the permissive terrain and its comparatively short lines of communication compared to NATO, Russia may hold an offensive advantage in a short-term conflict before NATO could fully mobilise its forces.[60]

Russia's land power advantage would be enhanced when operating under its capable Integrated Air Defence System (IADS), a key component of its defensive capabilities that offsets NATO's air power advantages.[61] It is assessed that Russia's IADS could disrupt any NATO air power intervention, but that it could be degraded over time by NATO leveraging its overall numerical and logistical advantages.[62] NATO's qualitative and quantitative naval advantages would be similarly balanced by Russia's naval posture, predicated on sea denial, littoral defence and protection of its submarine forces.[63] Russia's defences are assisted by its control of key strategic locations. Russia has improved its shore-based defensive systems and Black Sea Fleet capabilities, consolidating the naval balance of power in its favour in the Black Sea region.[64] In the Baltic, the strengthening of military capabilities in Kaliningrad, particularly its air and maritime anti-access/area denial (A2/AD) systems, will balance NATO's naval advantages.[65] Russian A2/AD capabilities are likely to balance NATO's air and naval superiority, providing defensive advantage, but may also enable Russian offensive action in the region. Ultimately, any NATO conventional offensive operations would carry very high risks owing to Russia's enhanced defensive capabilities; thus, the balance of conventional forces is deemed to favour the defence.

To assess the nuclear balance, one needs to consider whether a nuclear state has an assured capability to launch a retaliatory strike in the event of a nuclear war. Where both actors possess this capability, defence will have the advantage and stability should ensue.[66] A first-strike advantage could be attained by preventing the launch of unacceptable numbers of warheads, intercepting the weapons after launch, or some combination of the two. Looking first at the

potential of Russia and NATO to intercept weapons after launch. Space precludes a full assessment of NATO and Russia BMD capabilities, but academic consensus tends to the conclusion that US or NATO BMD will not be capable of defeating Russia's current and future strategic weapons systems, owing to their limited coverage and the historic and future development of BMD penetration aids, such as multiple independent re-entry vehicles (MIRVs).[54] Similarly, whilst Russia is undertaking steps to improve its BMD capabilities, it is assessed that they will not upset the present nuclear balance.[68] As Russian and NATO BMD are considered incapable of protecting against a peer strategic nuclear exchange, the question of whether either possess the capability to supress their nuclear forces 'left of launch' must now be considered.

The scale and variety of NATO and Russian nuclear systems make the prospect of either being able to sufficiently degrade its adversary's nuclear capabilities left of launch highly unlikely. Although capped by New START treaty limits, Russia still fields around 1,426 warheads deployed on 513 strategic launchers.[69] These systems include silo launchers, mobile transporter erector launchers (TELs), air-launched weapons, and submarine-launched ballistic missiles.[70] Additionally, Russia operates substantial sub-strategic nuclear forces that equate to a further 1,870 warheads, again deployed across a diverse range of delivery systems.[71] In comparison, the US provides the largest contribution to NATO's nuclear deterrent capability with its strategic nuclear forces also founded on a nuclear air- land- and submarine-based triad.[72] The US fields as many as 1,600 strategic warheads, with the UK and France together contributing roughly 400 more.[73] The size and diversity of these delivery systems, therefore, creates a significant challenge to achieving a disarming first strike.

Current studies contend that both NATO and Russia possess highly survivable deterrent capabilities. The survivability of Russia's nuclear deterrent is primarily derived through its extensive mobile strategic TELs and submarine-launched missile systems.[74] The Russian strategic nuclear warning and command-and-control (C2) system is similarly capable and survivable, adequate to assure retaliation in the event of an attack on its nuclear capabilities.[75] Whilst NATO does not field mobile TELs, it does possess three independent submarine-based nuclear systems, each with independent C2 systems and decision-making chains. The US deterrent alone is considered sufficiently capable of withstanding a nuclear attack to be able to deliver an unacceptable retaliatory strike.[76] Thus, neither actor possesses the capability to achieve offensive nuclear advantage either through a disarming strike, missile defences, or a combination of the two. Therefore, when considering the present balance of nuclear forces, both NATO and Russia possess assured deterrent capabilities, and thus the offence-defence balance favours defence.

When considering whether offence or defence has the advantage, it is argued that conventional force asymmetries balance each other and that whilst Russia may be able to make short-term offensive gains, NATO could overturn any advantage attained. Above all, both NATO and Russia possess assured nuclear deterrent capabilities. Thus, in the current

balance, defence has the advantage. Whilst both Russia and NATO claim to adopt defensive postures, these are not perceived by their adversary, indicating that defensive and offensive postures are not distinguishable. The current offence-defence balance between NATO and Russia, therefore, falls into World 2 of Jervis's Four Worlds model, as indicated in Figure 3.

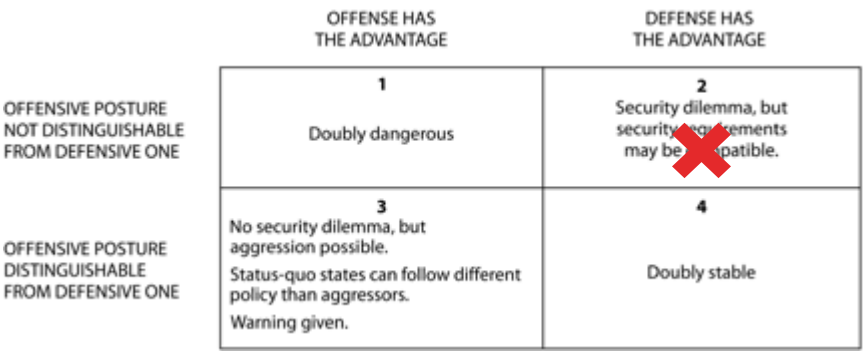

Figure 3: Current NATO–Russia Balance.[77]

Jervis contends that in this world, the prospect of conflict is reduced but that the security dilemma will operate, driven by the inability of offensive or defensive intent to be distinguished. He contends that cooperation is possible, but that careful diplomacy is required to realise any opportunities.[78] Having argued where the current balance rests, it is now possible to examine how hypersonic weapons may impact on this balance and, hence, understand the implications for stability between NATO and Russia.

Hypersonic Weapons and Posture Perception

Having established where the present military balance rests between NATO and Russian conventional and nuclear forces, the impact that introducing hypersonic weapons into the dyad may have on the balance will now be examined. The analysis will follow the methodology used in the previous section, beginning with an exploration of whether hypersonic weapons may allow NATO and Russia to disambiguate the other's posture. It will then move on to consider whether hypersonic weapons will alter the present defence dominance of the NATO-Russia balance. Finally, the section will conclude by situating the potential future offence-defence balance in the Four Worlds model and thereby draw conclusions on what the resultant future implications for stability may be.

Booth and Wheeler contend that weapons are not able to speak for themselves; rather they communicate through the perceptions of their interpreters.[79] This section will examine where each actor claims that hypersonic weapons will feature in their respective concept of military operations before reviewing how each perceives the intent that lies behind their competitors desire to field these systems. This will provide an understanding of whether hypersonic weapons will bring clarity to whether an actor is adopting an offensive or defensive posture or whether they may heighten the already existing ambiguity.

The United States has the most advanced hypersonic weapons programmes of any NATO nation, but it has yet to formally articulate what the mission requirements for its hypersonic weapons are.[80] There has been mention of them being used to enhance conventional deterrence, which would signal a defensive intent, but most often, they are described as offensive capabilities such as targeting adversary defences and C2 nodes, along with other well defended high value targets.[81] Because the West has not declared the mission requirements for these weapons, this leaves adversaries having to interpret how these weapons may be used. Even with a clearly stated defensive mission requirement, it is entirely possible that an adversary would interpret their development as offensive in nature, particularly given current levels of mistrust.[82] Russian observers have undoubtedly made up their minds on whether the US hypersonic weapons are offensively or defensively orientated, with Gerasimov having characterised the CPGS concept as an offensive capability.[83] The perceived offensive threat that US hypersonic weapons pose to Russia has led to them being explicitly listed in Russian deterrence policy as a threat that is to be 'neutralised' through nuclear deterrence.[84] Russia has also declared its intent to counter hypersonic weapons through the development of more advanced missile defences, with the forthcoming S-500 surface-air missile purported to have the capability to defeat hypersonic targets.[85] The intent to enhance its deterrent and defensive capabilities to counter US hypersonic weapons highlights the Russian perception that the US, and NATO, harbour malign intent. The lack of clarity over the mission requirements that the US and its NATO allies envisage for hypersonic weapons could be exacerbating Russian fear.

Russian hypersonic programmes are equally prone to ambiguity over whether they are being developed for offensive or defensive means. Russian hypersonic weapons development is driven by a perceived need to retain an assured nuclear strike capability that could reliably evade any US BMD.[86] Whilst the *Avangard* strategic nuclear HGV elicited consternation amongst some Western commentators because US defences cannot defeat it, it is this fact that allows it to contribute positively to strategic stability, although current defences are incapable of defeating present Russian ICBM capabilities.[87] Thus, *Avangard* is a logical addition to Russia's defensive capabilities. If *Avangard* was the only Russian hypersonic system under development, it could be argued that Russia's hypersonic weapons programme was defensively rather than offensively orientated. However, the development of the *Tsirkon* anti-ship and *Kinzhal* land attack missiles cast doubt on Russia's intentions.

Russia's tactical and intermediate range HCMs are of more concern to NATO than the *Avangard* strategic system. NATO analysis expounds upon the threats that systems such as *Tsirkon* and *Kinzhal* will pose to critical infrastructure, defensive systems, and C2 capabilities.[88] Their speed would greatly decrease warning times and could allow Russia to gain early advantage in a crisis. As with Russia, the threat posed by these weapons is deemed sufficient that NATO is seeking to enhance its BMD to be able to defeat these threats.[89] Another indicator that the West perceives Russian systems as offensively orientated is that Western officials, including the US Under Secretary of Defense for Research and Engineering, speak of the West lagging in hypersonic technology development.[90] A status quo power is likely to be concerned about

whether another state is increasing its military capabilities only when it believes that they could be used for offensive intent. Although Russia may claim that its hypersonic weapons are a component of its strategic deterrence concept and, therefore, defensive in nature, it is evident that this is not the view held in the West. Given Russia's recent history of interventions and the perception that it is a revanchist power, it is evident that NATO does not recognise Russia's claim that hypersonic weapons form part of a defensive posture.[91]

Both the West and Russia see each other as non-status quo actors. Whilst hypersonic weapons can be used in a deterrent or defensive operation, their inherently offensive nature only serves to heighten perceptions that those who seek them harbour aggressive motivations. Thus, hypersonic weapons do not resolve the current ambiguity surrounding whether an offensive posture can be distinguished from a defensive one. Ultimately, they are serving only to increase this ambiguity and, hence, further entrench mutual negative perceptions within the dyad that are precipitating a reaction towards developing defences for weapons that are yet to enter service.

Hypersonic Weapons and the Conventional Balance

It has been established that the current balance of conventional forces favours defensive operations and that any offensive action taken by either NATO or Russia would be exceptionally risky. Owing to their expense, these systems are not likely to be produced in great numbers and are likely to be reserved for very high-value targets that require rapid engagement or assured penetration of adversary defences. Such targets are, therefore, likely to include C2 facilities, A2/AD or anti-satellite capabilities, or regime leadership targets.[92] Russia's conventional hypersonic weapons are likely to be used in similar roles, with the key addition of both *Tsirkon* and *Kinzhal* potentially supplementing its maritime A2/AD capabilities. This section will assess how the conventional balance may be impacted by hypersonic weapons when used in these roles.

Hypersonic weapons have been espoused as a potential key to unlock advanced air and maritime A2/AD networks, but their utility in such a role is doubtful. There are three potential challenges to utilising hypersonic weapons to degrade air and maritime A2/AD systems. First, such systems are designed to be survivable. They comprise multiple layers provided by different platforms, including mobile units that can be camouflaged, dispersed, and rapidly change location. Thus, they present significant challenges for the supporting capabilities required to enable hypersonic strike missions.[93] The lack of development of the supporting capabilities necessary to enable hypersonic precision strike has been highlighted as a key issue in their employment.[94] Second, hypersonic weapons are likely to be very expensive and are not expected to be produced in sufficient numbers to reliably degrade an integrated defence system.[95] Third, and perhaps most critically in the case of Russia, A2/AD networks are classed as strategic defensive systems and their kinetic degradation could be highly escalatory.[96] The risks associated with escalation will be expanded on further later in this section, but the challenges of reliably degrading a strategically important, complex, and protected A2/AD network with a

limited number of expensive weapons is likely to mean that hypersonic weapons do not offer a credible option for this task.

In contrast, hypersonic weapons are likely to enhance the effectiveness of A2/AD systems, especially in the maritime environment. They are likely to enhance Russia's ability to hold NATO naval assets in the Baltic and Black Sea regions at higher risk and at much greater ranges. The expected best performance of Russia's current maritime A2/AD capability is thought to be around 300km at a speed of approximately Mach 2.5.[97] By contrast, the *Tsirkon* HCM has a potential range of up to 1,000km at speeds of up to Mach 8.[98] Striking at a target 300km away, the *Tsirkon* system could reduce flight times from around 330 seconds to just 108 seconds. The potential for the *Tsirkon* to be deployed on submarines and on land, as well as on surface ships, further increases the system's resilience against interdiction.

Presently, NATO does not possess the capability to intercept hypersonic missiles, although systems such as the US Terminal High Altitude Area Defense (THAAD) may offer a foundation on which to develop such a capability.[99] The US Missile Defence Agency requested a substantial funding uplift to aid research and development into the suite of technologies required to generate hypersonic missile defences.[100] However, these initiatives are at an early stage and their technological feasibility remains in question.[101] Hypersonic weapons are thus likely to offer significant advantages to Russia's defensive capabilities by reducing NATO surface fleet survivability in the Baltic and Black Sea regions. NATO maritime intervention will entail much greater risk until such time as defences against hypersonic anti-ship missiles are developed.

Further to the escalation risks associated with targeting A2/AD systems, it is likely that in the context of peer-to-peer conflict any use of hypersonic weapons will risk escalation towards nuclear confrontation. Russia's deterrent policy does not only specify hypersonic weapons as a threat against which Russia would employ nuclear deterrence, it also states that nuclear weapons may be used in response to attacks on any targets that could impinge on its nuclear capability, or the use of conventional weapons in a way that threatens the existence of the state.[102] A2/AD systems are assessed as potentially falling into this category, and it is highly likely that C2 facilities, anti-satellite technology, and leadership targets will too.[103] Thus, any NATO use of hypersonic weapons in the roles envisaged will be fraught with escalatory risk, particularly as Russia is assessed to have a lower threshold for the use of sub-strategic nuclear forces.[104] These forces will, in time, include hypersonic delivered warheads which will allow Russia to hold at risk a wider range of targets. NATO's use of hypersonic weapons is likely to be highly constrained by Russia's deterrence posture, which will itself be strengthened by the addition of dual-use hypersonic weapons.

Because NATO's threshold for the employment of sub-strategic nuclear weapons is considered to be higher than Russia's, there may be space for Russia to utilise hypersonic weapons with less fear of provoking a nuclear response.[105] This could create challenges for NATO, especially

since Russia may equip *Kinzhal* with both conventional and nuclear warheads, thus exacerbating issues of warhead ambiguity.[106] Conversely, the use of dual-capable systems by Russia may make their use in a conventional context much more challenging. Because these systems are designed to attack high-value targets, there is a risk that the compound effect of warhead and target ambiguity precipitate an escalatory response from NATO. This is likely to constrain Russia's use of conventional hypersonic weapons in a crisis. NATO has identified the need to adjust its deterrence posture considering hypersonic weapons, and so it is probable that Russian use may be further constrained in future.[107]

The current general balance of conventional forces results in neither NATO nor Russia enjoying a clear offensive advantage. Introducing hypersonic weapons into the dynamic may strengthen Russia's A2/AD posture, particularly in the maritime domain. Conversely, they are unlikely to offer an antidote to Russia's complex and dispersed air and maritime A2/AD systems. Whilst both NATO and Russian conventional hypersonic weapons systems are likely to offer the ability to engage high-value targets, their use will be greatly constrained by their potential escalatory effects. Thus, conventional hypersonic weapons appear not to fundamentally shift the conventional balance from defence to offence when considered in the peer-to-peer nuclear power context of the NATO–Russia dyad. This could change if the prospect of a defensive nuclear response is removed from the equation. Therefore, the potential for hypersonic weapons to critically degrade nuclear deterrent capabilities must now be considered.

Hypersonic Weapons and the Nuclear Balance

The present balance of nuclear forces favours defensive postures owing to neither NATO nor Russia having the capability to neutralise the other's nuclear forces. This section will follow the same analytical path by first examining whether hypersonic weapons present any benefits or challenges to missile defences before examining the credibility of fears, particularly amongst Russian leaders and analysts, that hypersonic weapons offer the capability to neutralise nuclear capabilities left of launch. Having then established the nuclear balance, this will then be married with the outcomes of the analysis of posture and the conventional force balance to situate the potential future balance in the Four Worlds model.

Strategic hypersonic weapons, such as the Russian *Avangard* HGV, are likely to heighten the challenge NATO faces of defending against strategic nuclear attacks. The weapon makes use of speed and an unpredictable flight path to ensure that it can penetrate any current or expected BMD.[108] Whilst both the US and Russia are working to develop defensive systems that can defeat hypersonic weapons, these technologies are at an even lower readiness level than the weapons themselves and, therefore, are unlikely to see service within the timeframe covered by this paper.[109] However, current missile defences are insufficient to neutralise current ICBMs so *Avangard*'s material impact on the current balance is limited.[110] A potential benefit may be that *Avangard* could ameliorate Russian fears of NATO BMD undermining its deterrent and, therefore, may improve its perception of the level of security it enjoys. Thus far, NATO and the

US have not detailed any intent to procure hypersonic nuclear weapons, an indication that despite Russian missile defence developments, there does not exist the same perception that these will undermine NATO's deterrent. Ultimately, current NATO and Russian missile defences are incapable of intercepting even a fraction of the weapons that could be used in a nuclear retaliatory strike, hypersonic or otherwise. This means that if hypersonic weapons are to defeat adversary nuclear capabilities, they must be capable of writing down a very significant proportion of their forces prior to launch.

Hypersonic weapons are likely to enhance the ability for actors to target elements of an adversary's nuclear capabilities, but not to the extent that they could achieve a disarming first strike. The speed and manoeuvrability of hypersonic missiles would likely allow them to penetrate any current defences situated around fixed targets, thus rendering them more vulnerable. However, this is not a new phenomenon and both NATO and Russia have long since taken precautions against such an eventuality. Potential passive defensive measures that are likely to offer challenges to using hypersonic weapons to target key capabilities are assessed to include 'mobility, redundancy, hardening, deception, concealment and dispersal'.[111] These techniques correlate with those used by NATO nuclear nations and Russia to protect their respective deterrent capabilities. As discussed earlier, the deterrent capability of each half of the dyad has redundancy designed into it using air- sea- and land-based systems. Thus, any attempt to gain nuclear advantage must be able to simultaneously impair all three elements to prevent a retaliatory strike that present and projected missile defences would not be capable of defending against. Hypersonic weapons provide a credible option for striking silo-based capabilities, of which Russia has about 158 and the US of the order of 400.[112] Projected Russian conventional hypersonic weapon capabilities will not have the reach to threaten US silo-based systems and so their only means of targeting them remains through ICBMs, exactly as is the case today.

The US CPGS system, if procured in sufficient numbers, could conceivably allow Russian silo-based launchers to be targeted. However, Russia's dispersed and concealed mobile systems, of which it possesses around 144, represent a very difficult target set that would require extremely capable supporting capabilities to facilitate any engagement, hypersonic or otherwise.[113] From the literature, it is not clear whether NATO possesses the enabling capabilities to be able to reliably target this complex target set, weaknesses in hypersonic enabling capabilities have previously been identified by the US government.[114] Finally, and critically, hypersonic weapons will be unable to target submarine-based nuclear deterrent capabilities once they have left port. Therefore, states that maintain a continuous at sea deterrent, such as Russia, the US, the UK, and France, will retain a nuclear retaliatory capability regardless of any projected developments in hypersonic technology.

Hypersonic weapons provide a more assured capability to defeat future developments in BMD technology. However, current ICBMs equipped with MIRVs and other penetration aids are considered equally able to offer an assured second-strike capability. Fears that hypersonic

weapons could provide first-strike advantage and thus undermine nuclear stability appear to be objectively unfounded given the size, scale, and survivability of NATO and Russia's strategic and sub-strategic nuclear forces. Hypersonic weapons are thus unlikely to dramatically alter the nuclear offence-defence balance from its status of defence dominance.

Implications and Conclusions

Having assessed how hypersonic weapons are likely to influence the relative ability to discern offensive from defensive postures, as well as their impact on the conventional and nuclear offence-defence balance, it is now possible to assess what this may mean for stability. Introducing hypersonic weapons into each actor's capability portfolios does not decrease the ambiguity that NATO and Russia are faced with when trying to discern the intentions of the other. Because mutual reactions clearly indicate that both harbour fears that these capabilities improve offensive capabilities, they are likely to breed more mistrust rather than less. The utility of conventional hypersonic weapons will be significantly constrained by their escalatory potential, and because they are unlikely to upset strategic stability, the assured defensive capabilities of half of the dyad will ensure that defence retains the advantage. If these findings are interpreted in the Four Worlds model, it can be shown that the balance is likely to shift from its present position owing to increased posture ambiguity, but that it does not move the balance into a different world. Figure 4 depicts the future balance in red, with the current balance indicated in grey.

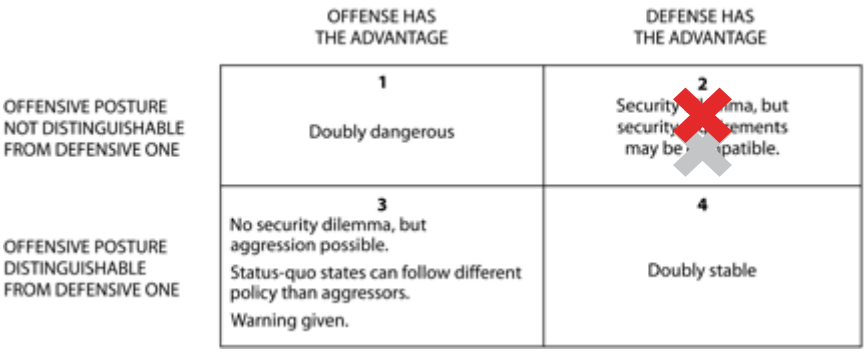

Figure 4: Future NATO–Russia Balance[115]

There are three key implications that arise from the analysis. First, the utility of conventional hypersonic weapons will be constrained by their escalatory potential. Because these systems are likely to be procured only in low numbers and they are likely to be expensive in comparison to other missile systems, they will be used only for the highest value targets. These targets are amongst those that both NATO and Russia have developed their deterrent posture to protect. Thus, employing hypersonic weapons in the roles for which they are best suited can only be done at great risk – a risk that both NATO and Russia will strive to avoid given the potential consequences of the realisation of that risk. This escalatory potential also limits their effectiveness as part of Russia's maritime A2/AD network. The issue of warhead

ambiguity driven by Russia's intent to field dual-capable missiles increases the risk of escalation and, therefore, decreases their practical utility. Because of their escalatory potential and the fact that hypersonic weapons have been shown not to undermine the assured second-strike capabilities, consideration ought to be given to whether the considerable investment in hypersonic weapons is worthwhile given the likely limited utility in a peer-to-peer nuclear context. Additionally, while these weapons may be useful in a non-peer conflict, where the escalatory risks are lower, it is likely that in this context, other less expensive and more readily available weapons systems may be better suited to the task.

Second, because hypersonic weapons are perceived to present a potential threat to high-value targets and because they are presently undefeatable by current BMD, they are likely to drive the development of nuclear capabilities and missile defences of both NATO and Russia. With regards to nuclear capabilities, the increase in salience of nuclear weapons as a counter to hypersonic weapons has already been evidenced by the inclusion of hypersonic weapons within Russia's State Policy on deterrence. NATO has also identified the need to review its deterrent posture in relation to hypersonic weapons. Whilst these developments may assist in deterring against the use of hypersonic weapons, any changes to posture must be carefully considered in the event that any unintended consequences are introduced that could undermine stability. Similarly, the intent of both Russia and NATO nations to develop BMDs that can engage hypersonic weapons has been made clear. Given that the impetus behind Russia's *Avangard* programme was provided by developments in US and NATO BMD, future missile defences capable of defeating hypersonic weapons are likely to precipitate adversary reactions. This factor is omitted from the US Congressional Research Service's most recent paper detailing the issues with hypersonic missile defences that members of Congress should consider.[116] Whilst developments in BMD technology to counter hypersonic weapons may improve defensive capabilities, the potential that they could impact strategic stability in the future is an area deemed worthy of very careful consideration by policy makers and analysts.

Third, although hypersonic weapons will not tilt the balance towards an unstable offensive dominant relationship, they are highly likely to drive the security dilemma between NATO and Russia owing to popular perceptions surrounding their offensive utility. Jervis contends that within 'World 2' the security dilemma will likely operate chiefly through the fact that postures cannot be distinguished, but that because defence has the advantage, the potential gains from offence are lower and, therefore, the potential for cooperation exists.[117] Because hypersonic weapons have been demonstrated to have little objective utility in a peer-to-peer nuclear power context owing to their escalatory risks and the fact that they do not undermine second-strike capabilities, it may be in the interests of both parties to seek to manage perceptions around each other's hypersonic weapons programmes. The US has already signalled its readiness to adjust its programme to ameliorate potential sources of instability by cancelling its development of the CTM programme. A less aggressive posture could potentially be signalled through a reduction in the number of weapons procured, or at least deployed, at any time. Such a move may require a method of positive verification, although again the potential for

this to occur has already been demonstrated by US verification of the Russian *Avangard* system through the New START treaty protocols.[118] Exploiting opportunities to manage the negative perceptions that each party holds of its adversary's hypersonic weapons programme will further assist in ameliorating the security dilemma.

This research paper set out to establish what impact emerging hypersonic weapon technology would have on the relationship between Russia and NATO. By using offence-defence balance theory to examine the current and potential future military balance, it is contended that hypersonic weapons are unlikely to dramatically alter the balance between these two nuclear armed adversaries. The advantages that hypersonic weapons promise cannot be realised owing to the significant risk of escalation towards nuclear conflict. However, the perceptions that hypersonic weapons could offer considerable offensive advantages are driving an increase in salience of nuclear weapons and missile defences within the strategies of both actors; these developments could engender future instability. The security dilemma that is currently operating could be eased by the management of perceptions. The benefits are clear and the potential for cooperation does exist; exploiting any future opportunities to improve perceptions will be key to slowing the cycle of action and reaction.

Perhaps the relationship of hypersonic weapons and great power competition is best encapsulated by Bernard Brodie's gunfighter analogy. If both fighters can draw their pistol and accurately deliver a knock-out blow, i.e. if offence has the advantage, then each is compelled to act first for fear of being disarmed. Hypersonic weapons will certainly be fast and may be assured of accurately striking their target, but they do not shift the balance in the favour of offence, for they do not remove that critical nuclear defence, which the duellist cannot be certain their opponent will not use in response. As Brodie put it, '… that restraint that was suicidal in one situation now becomes prudence, and it is trigger happiness that is suicidal'.[119] So it is for nuclear weapons and, in the case of great nuclear power competition, so it is for hypersonic weapons.

Notes

[1] Ronald O'Rourke, *Renewed Great Power Competition: Implications for Defense – Issue for Congress* (Washington D.C.: Congressional Research Service, 2021), 21-22.
[2] Susan Davis, *Hypersonic Weapons – A Technological Challenge for Allied Nations and NATO?* NATO Parliamentary Assembly Science and Technology Committee General Report. Brussels: NATO PA STC: 1, https://www.nato-pa.int (accessed April 2, 2021).
[3] James Acton, "Hypersonic Boost-Glide Weapons," *Science and Global Securit*y 23, No. 13 (2015): 191.
[4] Ivan Oelrich, "Cool Your Jets: Some perspective on the hyping of hypersonic weapons," *Bulletin of the Atomic Scientists* 76, No. 1 (2020): 43. and Cameron Tracy, "The Accuracy of Hypersonic Weapons: Media Claims Miss the Mark," Union of Concerned Scientists, https://allthingsnuclear.org (accessed March 29, 2021).
[5] Munich Security Conference, *Munich Security Report 2019* (Munich: Munich Security

Conference, 2019): 50, https://securityconference.org (accessed May 7, 2021). and Margot van Loon, Larry Wortzel, and Mark B. Schneider, "Hypersonic Weapons," American Foreign Policy Council Defense Technology Program Brief, No. 18 (2019): 2.

[6] Davis, *Hypersonic Weapons*, 3 James M. Acton, *Silver Bullet? Asking the Right Questions About Conventional Prompt Global Strike* (Washington, D.C.: Carnegie Endowment for International Peace, 2013): 131.

[7] Robert Jervis, "Cooperation Under the Security Dilemma," *World Politics* 30. No. 2 (1978): 186.

[8] Tim Dunne and Brian C. Schmidt, "Realism," in *The Globalization of World Politics*, 5th ed., eds J. Bayliss, S. Smith and P. Owens (Oxford: Oxford University Press, 2011), 90.

[9] Sean M. Lynn-Jones, "Preface," in *Offense, Defense and War*, eds M.E. Brown, O.R. Cote Jr., S.M. Lynn-Jones, and S.E. Miller (London: MIT Press, 2004), xi.

[10] James Acton, "Reclaiming Strategic Stability," in *Strategic Stability: Contending Interpretations*, eds E.A. Colby and M.S. Gerson (Carlisle Barracks, PA: Army War College Press, 2013), 128.

[11] Lynn-Jones, "Preface," xiv-xv.

[12] Jervis, "Cooperation," 194. and Stephen Van Evera, "Offense, Defense, and the Causes of War," in *Offense, Defense and War*, eds M.E. Brown, O.R. Cote Jr., S.M. Lynn-Jones, and S.E. Miller (London: MIT Press, 2004), 239-243.

[13] Lynn-Jones, "Preface," xv.

[14] Ken Booth and Nicholas J. Wheeler, *The Security Dilemma* (Basingstoke: Palgrave MacMillan, 2008), 4.

[15] Jervis, "Cooperation," 203.

[16] Keir A. Lieber, "Grasping the Technological Peace: The Offense-Defense Balance and International Security," *International Security* 25, No. 1 (2000): 73.

[17] James W. Davis Jr., "Correspondence: Taking Offense at Offense-Defense Theory," in *Offense, Defense and War*, eds M.E. Brown, O.R. Cote Jr., S.M. Lynn-Jones, and S.E. Miller (London: MIT Press, 2004), 306.

[18] Shaun M. Lynn-Jones, "Offense-Defense Theory and its Critics," *Security Studies* 4. No. 4 (1995): 672.

[19] Jervis, "Cooperation," 211.

[20] Acton, *Silver Bullet?*, 5.

[21] Ibid, 5-6.

[22] Besser, Hans-Ludwig, Dennis Goge, Michael Huggins, Alan Shaffer, and Dirk Zimper, "Hypersonic Vehicles: Game Changers for Future Warfare?" *Journal of the Joint Air Power Competence Centre* 24, spring/summer (2017): 19.

[23] Besser et al, "Hypersonic Vehicles," 20.

[24] Davis, *Hypersonic Weapons*, 3.

[25] Spenser A. Warren, "Avangard and Transatlantic Security," Centre for Strategic and international Studies, https://www.csis.org (accessed May 5, 2021).

[26] Kelley M. Sayler, *Hypersonic Weapons: Background and Issues for Congress* (Washington, D.C.: Congressional Research Service, 2020), 4.

[27] Sayler, *Hypersonic Weapons*, 4.

[28] Ibid, 8.

[29] Davis, *Hypersonic Weapons*, 8.
[30] Besser et al., "Hypersonic Vehicles," 17-18.
[31] Andreas Schmidt, "Hypersonic Threats: Hype or Game Changer for NATO's Deterrence?" *Journal of the Joint Air Power Competence Centre* 31, winter/spring (2021): 41.
[32] Davis, *Hypersonic Weapons*, 3.
[33] Stephen Reny, "Nuclear-Armed Hypersonic Weapons and Nuclear Deterrence," *Strategic Studies Quarterly* 14, No. 4 (2020): 54.
[34] Ibid, 26.
[35] Mark Episkopos, "Russia's Tsirkon Hypersonic Missile Keeps Inching Closer to Reality." The National Interest, https://nationalinterest.org (accessed April 3, 2021).
[36] Besser et al., "Hypersonic Vehicles," 22.
[37] Davis, *Hypersonic Weapons*, 8.
[38] Besser et al, "Hypersonic Vehicles," 18.
[39] Amy F. Woolf, *Russia's Nuclear Weapons: Doctrine, Forces and Modernization* (Washington, D.C.: Congressional Research Service, 2020), 26.
[40] Acton, *Silver Bullet?*, 111.
[41] Mark Hilborne, "Conventional Prompt Global Strike: Enhancing Deterrence?" *Air Power Review* 20, No. 2 (2017): 185.
[42] Woolf, *Russia's Nuclear Weapons*, 18.
[43] M. Elaine Bunn and Vincent A. Manzo, *Conventional Prompt Global Strike: Strategic Asset or Unusable Liability*, National Defence University, Strategic Forum Number 263 (Washington, D.C.: National Defense University, 2011), 16.
[44] Dean Wilkening, "Hypersonic Weapons and Strategic Stability," *Survival* 61, No. 5 (2019): 140.
[45] Russian Federation. *The Russian Federation's National Security Strategy*, Presidential Edict 683. (Moscow: Russian Federation, 2015), paragraph 15.
[46] Scott Boston, Michael Johnson, Nathan Beauchamp-Mustafaga, Yvonne K. Crane. *Assessing the Conventional Force Imbalance in Europe: Implications for Countering Russian Local Superiority*. RAND Corporation (Santa Monica: RAND Corporation, 2018), 11.
[47] Sokolosky, Richard, *The New NATO-Russia Military Balance: Implications for European Security* (Washington, D.C.: Carnegie Endowment for International Peace, 2017), 2.
[48] Sergey Sukhankin, "David vs Goliath: Kaliningrad Oblast as Russia's A2/AD 'Bubble'," *Scandinavian Journal of Military Studies* 2, No. 1 (2019): 95. and Anika Binnendijk, *Understanding Russian Black Sea Power Dynamics Through National Security Gaming*, RAND Corporation (Santa Monica: RAND Corporation, 2020), 25.
[49] Sokolosky, *NATO-Russia*, 3.
[50] North Atlantic Treaty Organisation, "Boosting NATO's Presence in the East and Southeast," NATO, https://www.nato.int (accessed May 12, 2021).
[51] Russian Federation, *Security Strategy*, paragraph 34.
[52] Kristen Ven Bruusgaard, "Russian Strategic Deterrence." *Survival* 58, No. 4 (2016): 20.
[53] MEMRI, "Russian Deputy Defense Minister Gerasimov," Russia Special Dispatch No. 7943, https://www.memri.org (accessed May 12, 2021).
[54] North Atlantic Treaty Organization, "Relations with Russia," NATO, https://www.nato.int

(accessed May 7, 2021).
[55] MEMRI, "Gerasimov".
[56] Russian Federation, *Security Strategy*, paragraph 15.
[57] Ibid.
[58] Boston et al., *Conventional Force*, 8.
[59] Sokolosky, *NATO-Russia*, 3.
[60] Boston et al, *Conventional Force*, 5-6.
[61] Scott Boston and Dara Masicott, *The Russian Way of Warfare*. RAND Corporation (Santa Monica: RAND Corporation, 2017), 4. and Boston et al., *Conventional Force*, 7.
[62] Ibid.
[63] Andrew S. Bowen, *Russian Armed Forces: Capabilities* (Washington, D.C.: Congressional Research Service, 2020), 2.
[64] Binnendijk, *Understanding*, 5.
[65] Sukhankin, "David vs Goliath," 95. and Sokolosky, *NATO-Russia*, 6.
[66] Jervis, "Cooperation," 198.
[67] Stephen J. Cimbala, *The New Nuclear Disorder* (Farnham: Ashgate, 2015), 224. and Oelrich, "Cool Your Jets," 43.
[68] Ferguson, Charles D., and Bruce W. MacDonald. *Nuclear Dynamics in a Multipolar Strategic Ballistic Missile Defence World*. Federation of American Scientists, 24 https://www.jstor.org (accessed May 13, 2021).
[69] Shannon N. Kile and Hans M. Kristensen, "10. World Nuclear Forces," in *SIPRI Yearbook 2020: Armaments, Disarmament and International Security* (Oxford: Oxford University Press, 2020), 336.
[70] Ibid, 103.
[71] Hans M. Kristensen and Matt Korda, "Russian Nuclear Forces, 2020." *Bulletin of the Atomic Scientists* 76, No. 2 (2020): 104.
[72] North Atlantic Treaty Organization, "NATO's Nuclear Deterrence Policy and Forces," NATO, https://www.nato.int (accessed May 13, 2021).
[73] Kile and Kristensen, "Nuclear Forces," 326.
[74] Dmitri Trenin, *Strategic Stability in the Changing World* (Moscow: Carnegie Endowment for International Peace, 2019), 9.
[75] Trenin, *Strategic Stability in the Changing World*, 9.
[76] Stephen J. Cimbala, *Nuclear Deterrence in a Multipolar World* (Abingdon: Routledge, 2019), 24.
[77] Jervis, "Cooperation," 211.
[78] Ibid, 212.
[79] Booth and Wheeler, *Security Dilemma*, 61.
[80] Sayler, *Hypersonic Weapons*, summary.
[81] Ibid, 4. and Besser et al, "Hypersonic Vehicles," 25. and Davis, *Hypersonic Weapons*, 9.
[82] Booth and Wheeler, *Security Dilemma*, 61.
[83] MEMRI, "Gerasimov".
[84] Russian Federation, Ministry of Foreign Affairs, *On Basic Principles of State Policy of the Russian Federation on Nuclear Deterrence*, Presidential Executive Order 355 (Moscow: Russian Federation, 2020), paragraph 12(a).

[85] TASS News Agency. "Experts name S-500 air defense system as possible 'antidote' to hypersonic weapons." TASS News Agency, https://tass.com (accessed April 12, 2021).
[86] Sayler, *Hypersonic Weapons*, 4 and Davis, *Hypersonic Weapons*, 11.
[87] Warren, "Avangard."
[88] Davis, *Hypersonic Weapons*, 9.
[89] Kelley M. Sayler and Stephen M. McCall, *Hypersonic Missile Defense: Issues for Congress* (Washington, D.C.: Congressional Research Service, 2021), 1.
[90] Michael T. Klare, "An 'Arms Race in Speed': Hypersonic Weapons and the Changing Calculus of Battle." *Arms Control Today* 49, no. 6 (2019): 10. and Nelson, Nicholas. "Understanding Hypersonics in an Era of Great Power Competition." DefenceIQ, https://www.defenceiq.com (accessed May 17, 2021).
[91] Dmitri Trenin, "Joe Biden's Foreign Policy and Russia," Carnegie Moscow Center, https://carnegie.ru (accessed May 28, 2021).
[92] Besser et al., "Hypersonic Vehicles," 25;. and Hilborne, "Global Strike," 184.
[93] Oelrich, "Cool Your Jets," 42.
[94] Acton, *Silver Bullet?*, 90.
[95] Ibid, 20-21.
[96] Michael Kofman, "It's Time to Talk About A2/AD: Rethinking the Russian Military Challenge," War on the Rocks, https://warontherocks.com (accessed May 18, 2021). and Boston and Massicot, *Russian Way of Warfare*, 6.
[97] Sukhankin, "David vs Goliath," 101. and Military Today, "P-800 Oniks," *Military Today*, http://www.military-today.com (accessed May 5, 2021).
[98] Davis, *Hypersonic Weapons*, 4.
[99] James M. Acton, "Hypersonic Weapons Explainer," Carnegie Endowment for International Peace, https://carnegieendowment.org (accessed June 4, 2021).
[100] United States, Department of Defense, "Fiscal Year (FY) 2020 Budget Estimates," Missile Defence Agency, 11 https://www.mda.mil (accessed May 4, 2021).
[101] Sayler and McCall, *Missile Defense*, 2.
[102] Russian Federation, *Nuclear Deterrence*, paragraph 19.
[103] Kofman, "A2/AD".
[104] Corbett, Andrew. Deterring a Nuclear Russia in the 21st Century, NATO Defence College Research Report 05/16 (2016), 6.
[105] Ibid.
[106] Sayler, *Hypersonic Weapons*, 13.
[107] North Atlantic Treaty Organization, "NATO Parliamentarians Highlight Need to Speed Up Defence Innovation and Prepare for Arrival of Hypersonic Weapons," NATO https://www.nato-pa.int (accessed May 29, 2021).
[108] Warren, "Avangard."
[109] Sayler and McCall, *Missile Defense*, 1. and Ferguson and MacDonald, *Nuclear Dynamics*, 24.
[110] Ibid, and Oelrich, "Cool Your Jets," 43.
[111] Travis Hallen and Michael Spencer, *Hypersonic Air Power* (Royal Australian Air Force. Canberra: Air Power Development Centre, 2018), 33.

[112] Hans M. Kristensen and Matt Korda, "United States Nuclear Forces, 2020." *Bulletin of the Atomic Scientists* 76, no. 1 (2020): 47;. and Kristensen and Korda, "*Russian Nuclear Forces*," 103.
[113] Kristensen and Korda, "*Russian Nuclear Forces*," 103.
[114] Acton, *Silver Bullet?*, 90.
[115] Jervis, "Cooperation," 211.
[116] Sayler and McCall, *Missile Defense*.
[117] Jervis, "Cooperation," 212.
[118] British Broadcasting Corporation, "Russia Deploys Avangard Hypersonic Missile System," British Broadcasting Corporation, https://www.bbc.co.uk (accessed April 2, 2021).
[119] Bernard Brodie quoted in Lawrence Freedman and Jeffrey Michaels, *The Evolution of Nuclear Strategy*, 4th ed. (London: Palgrave MacMillan, 2019), 232.

Books

Acton, James M. *Silver Bullet? Asking the Right Questions About Conventional Prompt Global Strike*. Washington, D.C.: Carnegie Endowment for International Peace, 2013.

Booth, Ken, and Nicholas J. Wheeler. *The Security Dilemma*. Basingstoke: Palgrave Macmillan, 2008.

Buzan, Barry. *An Introduction to Strategic Studies: Military Technology and International Relations*. Basingstoke: Macmillan, 1987.

Buzan, Barry. *People, States and Fear*. 2nd ed. Hemel Hempstead: Harvester Wheatsheaf, 1991.

Buzan, Barry and Eric Herring. T*he Arms Dynamic in World Politics*. London: Lynne-Rienner, 1998.

Cimbala, Stephen J. *Nuclear Deterrence in a Multipolar World*. Abingdon: Routledge, 2019.

Cimbala, Stephen J. *The New Nuclear Disorder*. Farnham: Ashgate, 2015.

Freedman, Lawrence, and Jeffrey Michaels. *The Evolution of Nuclear Strategy*. 4th ed. London: Palgrave Macmillan, 2019.

Fuller, J.F.C. *Armament and History*. New York: De Capo Press, 1998.

Fuller, J.F.C. *Thunderbolts*. London: Skeffington and Son, 1946.

Glaser, Charles L. *Rational Theory of International Politics: The Logic of Competition and Cooperation*. Princeton: Princeton University Press, 2010. Accessed November 25, 2020. ProQuest Ebook Central.

Thucydides. *History of the Peloponnesian War*. London: Penguin, 1972.

Chapters

Acton, James. "Reclaiming Strategic Stability." In *Strategic Stability: Contending Interpretations*, edited by E.A. Colby and M.S. Gerson, 117-146. Carlisle Barracks, PA: Army War College Press, 2013.

Cohen, Eliot. "Technology and Warfare." In *Strategy in the Contemporary World*. 2nd ed., edited by J. Bayliss, J. Wirtz, C.S. Gray and E. Cohen, 141-159. Oxford: Oxford University Press, 2007.

Davis Jr., James W. "Correspondence: Taking Offense at Offense-Defense Theory." In *Offense, Defense and War*, edited by M.E. Brown, O.R. Cote Jr., S.M. Lynn-Jones and S.E. Miller, 305-332. London: MIT Press, 2004.

Dunne, Tim, and Brian C. Schmidt. "Realism." In *The Globalization of World Politics*. 5th ed., edited by J. Bayliss, S. Smith and P. Owens, 84-99. Oxford: Oxford University Press, 2011.

Glaser, Charles L. and Chaim Kaufmann. "What is the Offense-Defense Balance and Can We Measure It?" In *Offense, Defense and War*, edited by M.E. Brown, O.R. Cote Jr., S.M. Lynn-Jones and S.E. Miller, 266-304. London: MIT Press, 2004.

Kile, Shannon N., and Hans M. Kristensen. "10. World Nuclear Forces." In *SIPRI Yearbook 2020: Armaments, Disarmament and International Security*, 325-393. Oxford: Oxford University Press, 2020).

Lynn-Jones, Sean M. "Preface." in *Offense, Defense and War*, edited by M.E. Brown, O.R. Cote Jr., S.M. Lynn-Jones and S.E. Miller, xi-xxxviii. London: MIT Press, 2004.

Nicholls, David J. "Cruise Missiles and War." In *The Technological Arsenal*, edited by W.C. Martel, 107-128. Washington, D.C.: Smithsonian Institution press, 2001.

Olsen, John Andreas. "Introduction: The New Face of War." In *Routledge Handbook of Air Power*, edited by J.A. Olsen, 1-10. Abingdon: Routledge, 2018.

Quester, George H. "Offense and Defense in the International System." In *Offense, Defense and War*, edited by M.E. Brown, O.R. Cote Jr., S.M. Lynn-Jones and S.E. Miller, 51-65. London: MIT Press, 2004.

Sutyagin, Igor. "Russian Air Power." In *Routledge Handbook of Air Power*, edited by J.A. Olsen, 313-326. Abingdon: Routledge, 2018.

Van Evera, Stephen. "Offense, Defense, and the Causes of War," In *Offense, Defense and War*, edited by M.E. Brown, O.R. Cote Jr., S.M. Lynn-Jones and S.E. Miller, 227-265. London: MIT Press, 2004.

Articles

Acton, James. "Hypersonic Boost-Glide Weapons." *Science and Global Security* 23, No. 13 (2015): 191-219.

Arnold, John-Michael. "NATO's Readiness Action Plan: Strategic Benefits and Outstanding Challenges." *Strategic Studies Quarterly* 10, No. 1 (2016): 74-105.

Bartles, Charles K. "Russian Threat Perception and the Ballistic Missile Defense System." *The Journal of Slavic Military Studies* 30, No. 2 (2017): 152-69.

Besser, Hans-Ludwig, Dennis Goge, Michael Huggins, Alan Shaffer and Drik Zimper. "Hypersonic Vehicles: Game Changers for Future Warfare?" *Journal of the Joint Air Power Competence Centre* 24, spring/summer (2017): 11-27.

Bousquet, Antoine and Jairus Victor Grove. "The Best of all Possible Nuclear Worlds (Or how Matthew Kroenig Learned to Stop Worrying and Love the Bomb) Review of Central European Affairs." *New Perspectives* 28, No. 1 (2020): 89-94.

Bruusgaard, Kristen Ven. "Russian Strategic Deterrence." *Survival* 58, No. 4 (2016): 7-26.

Hilborne, Mark. "Conventional Prompt Global Strike: Enhancing Deterrence?" *Air Power Review* 20, No. 2 (2017), 182-91.

Jervis, Robert. "Cooperation Under the Security Dilemma." *World Politics* 30. No. 2 (1978): 167-214.

Klare, Michael T. "An 'Arms Race in Speed': Hypersonic Weapons and the Changing Calculus of Battle." *Arms Control Today* 49, No. 6 (2019): 6-13.

Kristensen, Hans M. and Korda, Matt. "Russian Nuclear Forces, 2020." *Bulletin of the Atomic Scientists* 76, No. 2 (2020): 102-17.

Kristensen, Hans M. and Korda, Matt. "United States Nuclear Forces, 2020." *Bulletin of the Atomic Scientists* 76, No. 1 (2020): 46-60.

Lieber, Keir A. "Grasping the Technological Peace: The Offense-Defense Balance and International Security." *International Security* 25, No. 1 (2000): 71-104.

Lynn-Jones, Shaun. "Offense-Defense Theory and Its Critics." *Security Studies* 4, No. 4 (1995): 660-91.

Matsaberidze, David. "Russia vs. EU/US through Georgia and Ukraine." *Connections* 14, no. 2 (2015): 77-86. Accessed April 14, 2021. http://www.jstor.org/stable/26326399.

Oelrich, Ivan. "Cool your jets: Some perspective on the hyping of hypersonic weapons." *Bulleting of the Atomic Scientists* 76, No. 1 (2020): 37-45.

Reny, Stephen. "Nuclear-Armed Hypersonic Weapons and Nuclear Deterrence." *Strategic Studies Quarterly* 14, No. 4 (2020): 47-73. doi:10.2307/26956152.

Schmidt, Andreas. "Hypersonic Threats: Hype or Game Changer for NATO's Deterrence?" *Journal of the Joint Air Power Competence Centre* 31, winter/spring (2021): 39-46.

Skriba, Andrei. "Russian Strategy towards the Post-Soviet Space in Europe: Searching for Balance between Economy, Security, and Great Power Attractiveness." *Strategic Analysis* 40, No. 6 (2016): 604-18.

Sukhankin, Sergey. "David vs Goliath: Kaliningrad Oblast as Russia's A2/AD 'Bubble'," *Scandinavian Journal of Military Studies* 2, No. 1 (2019): 95-110.

Wilkening, Dean. "Hypersonic Weapons and Strategic Stability." *Survival* 61, No. 5 (2019): 129-48.

Williams, Heather. "Asymmetric arms control and strategic stability: Scenarios for limiting hypersonic glide vehicles." *Journal of Strategic Studies* 42, No. 6 (2019): 789-813.

Papers

Binnendijk, Anika. *Understanding Russian Black Sea Power Dynamics Through National Security Gaming*. RAND Corporation. Santa Monica: RAND Corporation, 2020.

Borrie, John, Amy Dowler and Pavel Podvig. *Hypersonic Weapons: A Challenge and Opportunity for Strategic Arms Control*. United Nations Institute for Disarmament Research. Geneva: UNIDIR, 2019.

Boston, Scott, Michael Johnson, Nathan Beauchamp-Mustafaga, Yvonne K. Crane. *Assessing the Conventional Force Imbalance in Europe: Implications for Countering Russian Local Superiority*. RAND Corporation. Santa Monica: RAND Corporation, 2018.

Boston, Scott and Massicot, Dara. *The Russian Way of Warfare*. RAND Corporation. Santa Monica: RAND Corporation, 2017.

Bowen, Andrew S. *Russian Armed Forces: Capabilities*. Washington, D.C.: Congressional Research Service, 2020.

Bronk, Justin. *Modern Russian and Chinese Integrated Air Defence Systems*. Royal United Services Institute. London: RUSI, 2020.

Bunn, M. Elaine and Manzo, Vincent A. *Conventional Prompt Global Strike: Strategic Asset or Unusable Liability?* National Defence University, Strategic Forum Number 263. Washington, D.C.: National Defense University, 2011.

Corbett, Andrew. *Deterring a Nuclear Russia in the 21st Century*. NATO Defence College Research Report 05/16 (2016). Accessed February 17, 2021. http://www.ndc.nato.int/research/research.php?icode=0#.

Davis, Susan. *Hypersonic Weapons – A Technological Challenge for Allied Nations and NATO?* NATO Parliamentary Assembly Science and Technology Committee General Report. Brussels: NATO PA STC. Accessed April 2, 2021. https://www.nato-pa.int/document/2020-revised-draft-report-hypersonic-weapons-davis-039-stc-20-e-rev-1.

Ferguson, Charles D., and Bruce W. MacDonald. *Nuclear Dynamics in a Multipolar Strategic Ballistic Missile Defence World*. Federation of American Scientists. Accessed May 13, 2021. https://www.jstor.org/stable/pdf/resrep18935.11.pdf.

Gurganus, Julia and Eugene Rumer. *Russia's Global Ambitions in Perspective*." Carnegie Endowment for International Peace Working Paper. Washington, D.C.: Carnegie Endowment for International Peace, 2019). Accessed April 5, 2021. https://carnegieendowment.org/files/RumerGurganus_Perspective_final.pdf.

Hallen, Travis and Michael Spencer. *Hypersonic Air Power*. Royal Australian Air Force. Canberra: Air Power Development Centre, 2018. Accessed 20 May, 2021. https://airpower.airforce.gov.au/publications/hypersonic-air-power.

Kelly, Terrence, David C. Gompert, and Duncan Long. *Smarter Power, Stronger Partners, Volume I: Exploiting U.S. Advantages to Prevent Aggression*. Santa Monica, CA: RAND Corporation, 2016.

Munich Security Conference. *Munich Security Report 2019*. Munich: Munich Security Conference, 2019. Accessed May 7, 2021. https://securityconference.org/assets/02_Dokumente/01_Publikationen/MunichSecurityReport2019.pdf.

O'Rourke, Ronald. *Renewed Great Power Competition: Implications for Defense – Issue for Congress*. Washington, D.C.: Congressional Research Service, 2021.

Russian Federation. Ministry of Foreign Affairs. *On Basic Principles of State Policy of the Russian Federation on Nuclear Deterrence*. Presidential Executive Order 355. Moscow: Russian Federation, 2020.

Russian Federation. *The Russian Federation's National Security Strategy*. Presidential Edict 683. Moscow: Russian Federation, 2015. Accessed March 20, 2021. http://www.ieee.es/Galerias/fichero/OtrasPublicaciones/Internacional/2016/Russian-National-Security-Strategy-31Dec2015.pdf.

Sayler, Kelley M. *Hypersonic Weapons: Background and Issues for Congress*. Washington, D.C.: Congressional Research Service, 2020.

Sayler, Kelley M. and Stephen M. McCall. *Hypersonic Missile Defense: Issues for Congress*. Washington, D.C.: Congressional Research Service, 2021.

Sokolosky, Richard. *The New NATO-Russia Military Balance: Implications for European Security*. Washington, D.C.: Carnegie Endowment for International Peace, 2017.

Speier Richard H., George Nacouzi, Carrie A. Lee, Richard M. Moore. *Hypersonic Missile Nonproliferation: Hindering the Spread of a New Class of Weapons*. Santa Monica, CA: RAND Corporation, 2017. Accessed March 21, 2021. https://www.rand.org/pubs/research_reports/RR2137.html.

Trenin, Dmitri. *Strategic Stability in the Changing World*. Moscow: Carnegie Endowment for International Peace, 2019.

United Kingdom. Development, Concepts and Doctrine Centre. *Future Security Challenges in the Baltic Sea Region*. Shrivenham: DCDC, 2015.

United Kingdom. Development, Concepts and Doctrine Centre. *Global Strategic Trends: The Future Starts Today*. 6th ed. Shrivenham: DCDC, 2018.

United Kingdom. House of Commons Defence Committee. *Missile Misdemeanours: Russia and the INF Treaty*. London: HM Government, 2019.

United Kingdom. HM Government. *Global Britain in a competitive age: The Integrated Review of Security, Defence, Development and Foreign Policy*. London: HM Government, 2021.

United Kingdom. Ministry of Defence. *Defence in a Competitive Age*. London: HM Government, 2021.

United States Congress. Senate Committee on Armed Services. *Testimony of John E. Hyten*. Hearing on United States Strategic Command and United States Northern Command. Accessed April 7, 2021. https://www.armed-services.senate.gov/imo/media/doc/Hyten_02-26-19.pdf.

United States. Office of the Director of National Intelligence. *Annual Threat Assessment of the US Intelligence Community*. Washington, D.C.: Office of the Director of National Intelligence, 2021.

Van Loon, Margot, Larry Wortzel, and Mark B. Schneider. *Hypersonic Weapons*. American Foreign Policy Council Defense Technology Program Brief, no. 18 (2019).

Woolf, Amy F. *Russia's Nuclear Weapons: Doctrine, Forces and Modernization*. Washington, D.C.: Congressional Research Service, 2020.

Web Pages

Acton, James M. "Hypersonic Weapons Explainer." Carnegie Endowment for International Peace. Accessed June 4, 2021. https://carnegieendowment.org/2018/04/02/hypersonic-weapons-explainer-pub-75957#:~:text=ACTON%3A%20A%20hypersonic%20weapon%20is%20anything%20that%20travels,mean%20one%20of%20two%20different%20kinds%20of%20technologies.

Bosbotinis, James. "'Fire for Effect': Russia's Growing Long Range Strike Capabilities." Wavell Room. Accessed April 10, 2021. https://wavellroom.com/2018/09/05/fire-for-effect-russias-growing-long-range-strike-capabilities-and-its-implications/.

British Broadcasting Corporation. "Russia Deploys Avangard Hypersonic Missile System." British Broadcasting Corporation. Accessed April 2, 2021. https://www.bbc.co.uk/news/world-europe-50927648.

Chuter, Andrew. "British Military Scramble to Speed Up Work on Hypersonic Weapons, Engines." Defense News. Accessed April 9, 2021. https://www.defensenews.com/global/europe/2019/07/18/british-military-scrambles-to-speed-up-work-on-hypersonic-engines-weapons/.

Episkopos, Mark. "Russia's Tsirkon Hypersonic Missile Keeps Inching Closer to Reality." The National Interest. Accessed April 3, 2021. https://nationalinterest.org/blog/buzz/russia%E2%80%99s-tsirkon-hypersonic-missile-keeps-inching-closer-reality-177512.

Kofman. Michael. "It's Time to Talk About A2/AD: Rethinking the Russian Military Challenge." War on the Rocks. Accessed May 18, 2021. https://warontherocks.com/2019/09/its-time-to-talk-about-a2-ad-rethinking-the-russian-military-challenge/.

Kristensen, Hans M., and Matt Korda. "Nuclear Notebook: United States Nuclear Forces, 2020." Bulletin of the Atomic Scientists. Accessed May 14, 2021. https://thebulletin.org/premium/2020-01/nuclear-notebook-united-states-nuclear-forces-2020.

Maloney, Catherine. "Hypersonics: Changing the NATO Deterrence Game." Joint Air Power

Competence Centre. Accessed May 28, 2021. https://www.japcc.org/hypersonics-changing-the-nato-deterrence-game/.

MEMRI. "Russian Deputy Defense Minister Gerasimov." Russia Special Dispatch No. 7943. Accessed May 12, 2021. https://www.memri.org/reports/russian-first-deputy-defense-minister-gerasimov-our-response-based-active-defense-strategy.

Military Today. "P-800 Oniks." Military Today. Accessed May 5, 2021. http://www.military-today.com/missiles/p800_oniks.htm.

Missile Defense Project. "Trident D-5." Missile Threat, Center for Strategic and International Studies. Accessed April 2, 2021. https://missilethreat.csis.org/missile/trident/.

Naval Technology. "Trident II D5 Fleet Ballistic Missile." Naval Technology. Accessed April 1, 2021. https://www.naval-technology.com/projects/trident-ii-d5-fleet-ballistic-missile/.

Nelson, Nicholas. "Understanding Hypersonics in an Era of Great Power Competition." DefenceIQ. Accessed May 17, 2021. https://www.defenceiq.com/air-land-and-sea-defence-services/articles/understanding-hypersonics-in-an-era-of-great-power-competition.

North Atlantic Treaty Organization. "Boosting NATO's Presence in the East and Southeast." NATO. Accessed May 12, 2021. https://www.nato.int/cps/en/natohq/topics_136388.htm.

North Atlantic Treaty Organization. "Enhanced Forward Presence." NATO. Accessed April 13, 2021. https://shape.nato.int/efp.

North Atlantic Treaty Organization. "Member Countries." NATO. Accessed April 5, 2021. https://www.nato.int/cps/en/natohq/topics_52044.htm.

North Atlantic Treaty Organization. "NATO's Nuclear Deterrence Policy and Forces." NATO. Accessed May 13, 2021. https://www.nato.int/cps/en/natohq/topics_50068.htm.

North Atlantic Treaty Organization. "NATO Parliamentarians Highlight Need to Speed Up Defence Innovation and Prepare for Arrival of Hypersonic Weapons." NATO. Accessed May 29, 2021. https://www.nato-pa.int/news/nato-parliamentarians-highlight-need-speed-defence-innovation-and-prepare-arrival-hypersonic.

North Atlantic Treaty Organization. "Relations with Russia." NATO. Accessed May 7, 2021. https://www.nato.int/cps/en/natolive/topics_50090.htm.

OpenStreetMap. "OS Maps-Radius." Accessed April 11, 2021. https://jopf.re/osmaps-radius/.
Putin, Vladimir. "Presidential Address to the Federal Assembly." Russian Federation.

Accessed April 12, 2021. http://en.kremlin.ru/events/president/news/56957.

TASS News Agency. "Experts name S-500 air defense system as possible 'antidote' to hypersonic weapons." TASS News Agency. Accessed April 12, 2021. https://tass.com/defense/1236865.

The Economist. "In the Balkans, NATO Has Outmuscled Russia." The Economist. Accessed April 5, 2021. https://www.economist.com/europe/2015/12/11/in-the-balkans-nato-has-outmuscled-russia.

Tracy, Cameron. "The Accuracy of Hypersonic Weapons: Media Claims Miss the Mark." Union of Concerned Scientists. Accessed March 29, 2021. https://allthingsnuclear.org/ctracy/the-accuracy-of-hypersonic-weapons-media-claims-miss-the-mark.

Trenin, Dmitri. "Joe Biden's Foreign Policy and Russia." Carnegie Moscow Center. Accessed May 28, 2021. https://carnegie.ru/commentary/83270.

United States. Department of Defense. "Selected Acquisition Report (SAR): Tactical Tomahawk RGM-109E/UGM-109E Missile (TACTOM)." US Department of Defense. Accessed April 9, 2021. https://apps.dtic.mil/dtic/tr/fulltext/u2/1019558.pdf.

United States. Department of Defense. "Fiscal Year (FY) 2020 Budget Estimates." Missile Defence Agency. Accessed May 4, 2021. https://www.mda.mil/global/documents/pdf/budgetfy20.pdf.

Walton, Timothy. "Why We Need the Advanced Hypersonic Weapon." War on the Rocks. Accessed March 29, 2021. https://warontherocks.com/2014/06/why-we-need-advanced-hypersonic-weapon/.

Warren, Spenser A. "Avangard and Transatlantic Security." Centre for Strategic and international Studies. Accessed May 5, 2021. https://www.csis.org/blogs/post-soviet-post/avangard-and-transatlantic-security.