Hypersonic Missiles and Arms Control

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In today's world, weapons are being developed that only 50 years ago would seem unthinkable; weaponized computer viruses, space weapons, unmanned aerial vehicles and other automated weapons. One of the greatest leaps in weapons technology occurred when ballistic missiles, specifically Intercontinental Ballistic Missiles, became developed and tested enough to be deployable. No longer did a state need to be geographically close to an adversary to strike it; the theatre of warfare went global. Due to the inherent risks, strategic value, and destabilizing effects of such weapons, ballistic missile technology has been subjected to an exceptionally large amount of arms control agreements, with hundreds of states coming together to reduce, limit, and outlaw aspects of ballistic missiles and the payloads they carry.

However, will the same mechanisms and way of thinking about arms control hold for the weapons of the future? Can states approach cyber weapons, space weapons, and weapons yet thought of in the same manner as it has the weapons of the past? The future of arms control isn't necessarily set in stone.

This paper will argue that arms control is the same it has ever been, and states will continue to conceive of it similarly to the past even in the face of new, more advanced weapons. First, a review of the relevant arms control literature is examined to establish a baseline regarding past and current conceptions of arms control, and also examine literature pertaining to our case study. Next, a case study is performed through examining hypersonic weapons, consisting of boost-glide vehicles and cruise missile technology, in the context of how best to subject them to arms control. Finally, issues in arms control compliance are examined and contextualized.

Literature Review

Our research has yielded that states participate in arms control primarily to avoid a security dilemma. Secondary motivating factors include reducing the cost of maintaining certain weapon systems, and reducing the risk of certain weapon systems from being used against them. Our team defines a

security dilemma as a situation in which actions by a state intended to strengthen its security, such as increasing its military strength or making alliances, lead other states to respond with similar measures, thereby increasing the odds of conflict among states rather than reducing them.

This definition was first established by the German scholar John H. Herz in his 1951 book *Political Realism and Political Idealism*. British historian Herbert Butterfield described the same situation in his *History and Human Relations*, but referred to it as the "absolute predicament and irreducible dilemma". In John Herz's words, the security dilemma is "A structural notion in which the self-help attempts of states to look after their security needs tend, regardless of intention, to lead to rising insecurity for others as each interprets its own measures as defensive and measures of others as potentially threatening".

In a system of sovereign states with the capability to build and maintain sizable armed forces, states cannot be sure that their rivals will not attempt to achieve military superiority. States often interpret incoming information about the military capabilities of rivals as threatening because of the absence of trust. Evidence of a new military program or spending by one state requires other states to respond in kind to prevent the other side from achieving superiority. This security dilemma can produce an arms race, endangering the diplomatic relations between states, raising the probability and severity of crises.

Arms control is an attempt to mitigate these security dilemma. Early theorists defined arms control in the broadest sense to refer to all forms of military cooperation between potential enemies in the interest of ensuring international stability. As Hedley Bull put it, arms control is "cooperation between antagonistic pairs of states in the military field, whether this cooperation is founded upon interests that are exclusively those of the cooperating states themselves or on interests that are more widely shared." Arms control analysts of the early 1960s were in agreement that the objectives of arms control were threefold. For Thomas Schelling and Morton Halperin, they were reducing the likelihood of war, reducing the political and economic costs of preparing for war, and minimizing the scope and violence of war if it occurred. Hedley Bull visualized similar objectives for arms control: to contribute to international security

and stop the drift to war; to release economic resources otherwise squandered in armaments; and to preclude preparing for war, which is morally wrong.

Our research has found that nations expect arms control measures to prevent both arms racing and war at a minimum. Until recently however, political leaders and the media used a more limited definition. Arms control was widely recognized as a set of activities dealing with specific steps to control related weapon systems, codified in formal agreements or treaties. Many analysts and much of the general public during the Cold War focused on the bilateral arms control negotiations between the United States and the Soviet Union. They came to expect that arms control required a formal treaty, a system of inspections to ensure compliance, and an enforcement mechanism to compel compliance. But those three elements are not always necessary for arms control. Arms control is a process involving specific, declared steps by a state to enhance security through cooperation with other states. These steps can be unilateral, bilateral, or multilateral. Cooperation can be implicit as well as explicit.

There is already an academic discussion regarding arms control and hypersonic weapon technology. Three scholars from three of the states developing hypersonic technology; Mark Gubrud from the United States, Rajaram Nagappa from India, and Tong Zhao from China; discuss the implications of a hypersonic race on states' nuclear capabilities and nuclear deterrence. The articles are split on the view that one state developing hypersonic weapons, be it a boost-glide vehicle or cruise missile, threatens the nuclear forces of the others and undermines their confidence in their nuclear arsenals.

Mark Gubrud, in his article, outlines an argument for how developing hypersonic weapons technology could spark another arms race, and how great hypersonic weapons sound for a state's strategic forces. Gubur argues that hypersonic weapons likely won't replace ballistic missiles due to high costs, but have strategic value in their ability to avoid early detection systems, ability to strike strategic targets such as missile silos or airfields, and their ability to be deployed as a conventional prompt global strike. However, Gubur sees the strategic value of hypersonic weapons outweighed by their costs (political and economic) and the potential for another global arms race, advocating for a test ban on hypersonic

weapons so there is still the ability for development of peaceful hypersonic technology such as hypersonic spacecraft for civilian scientific use.

Tong Zhao, a scholar from China, has a similar argument to Gubrud. His argument is simple: if relations between weaker and stronger nuclear states, such as the United States and China, are to remain stable, maintaining credible mutually assured destruction is paramount. Zhao sees hypersonic missiles as threatening that ability; "But nations' faith in the survivability of their nuclear deterrents could be seriously undermined by hypersonic missiles-either boost-glide systems or hypersonic cruise missiles-armed with conventional warheads" (Zhao 2015). Zhao is also concerned with the promptness of the weapon, seeing it as its greatest strategic capability, but also its greatest source of risk, arguing that the speed of the weapon offers only short windows of opportunity for decision makers and would likely lead to risky decision making, which isn't helpful when using a strategic weapon against strategic targets (Zhao 2015). Zhao expresses some doubt that a test ban could work, due to difficulties in defining the technical specifications of hypersonic technology, and instead suggests a kind of targeting ban, where states pursue "unilateral risk reduction measures" through not developing strategies using hypersonic weapons against certain strategic targets in other states (Zhao 2015).

Rajaram Nagappa from India disagrees fundamentally with the other two scholars, arguing that hypersonic technology, "even if it is perfected, will not add much to the security threats already posed by deployed weapon systems such as ballistic missiles" (Nagappa 2015). Nagappa believes that because determining what kind of warhead a hypersonic weapon is carrying (nuclear or conventional) can be difficult after a launch is detected and that the high degree of maneuverability doesn't allow targets to be tracked as effectively as ballistic missile targets can create uncertainty with the weapon, and will likely be conceived of by decision makers the same ballistic missiles are (Nagappa 2015). He is essentially arguing that the ambiguity of the weapon and the missions it could be deployed for contribute to general ambiguity of how the weapon is intended to be used by the state. Nagappa argues against a test ban, arguing that states developing this technology do so as it plays a large role in future security plans and won't support a test ban until after fully testing and finishing development of the weapon. Nagappa

instead argues, as deterrence can only be maintained with fully-tested weapons and those capabilities are demonstrated to other states, that enacting confidence-building measures similar to the ones in place for traditional ballistic missiles.

Case Study

Hypersonic technology has been in development in the United States since the 1990's. The X-51 was the one of the first hypersonic missiles developed. This missile is designed to be able to reach speeds up to Mach 5 and operate at 70,000 feet altitude (Acton 2015). The X-51 is 25 feet long and has an empty weight of 4,000 pounds. The X-51 completed its first test flight on May 26 2010 and on May 1, 2013 flew at its top speed of Mach 5 for 210 seconds, the longest reported hypersonic flight to date. Currently the missile can be carried by a B-52 until it is over the Pacific Ocean and is released. X-51 technology will be used in the High Speed Strike Weapon (HSSW) that is being developed and planned to be operational in 2020. This HSSW will fly at Mach 5-6 and will be able to be carried by an F-35 or a B-2 bomber.

More recently the United States has been developing the HTV 1 and HTV 2. The hypersonic technology vehicle (HTV) 1 was being developed by the US Defense Advanced Research Projects Agency but was discontinued in 2010 after unsuccessful test flights (Acton 2015). DARPA continued and developed the HTV 2. This hypersonic vehicle had its first launch on April 22, 2010 and was supposed to fly 4,800 miles at Mach 20 but the flight only lasted 9 minutes until signal was lost. The second test run of the HTV occurred on August 11, 2011 and the missile successfully separated from the booster but contact was again lost nine minutes into the 30 minute mission. No other test flights of the HTV 2 were scheduled.

The Advanced Hypersonic Weapon (AHW) is the most recent hypersonic weapon to be tested by the United States. In November of 2011 the weapon successfully traveled 2,400 miles thus making it the first successful flight to go over a couple hundred miles (Acton 2015). A second test occurred in August

of 2014 but failed due to a problem with the boosters. Department of Defense budget reports indicate that two more tests are scheduled for this year and 2019.

Russia and China are both developing hypersonic weapon technology as well. The WU-14 is China's known project into the field. This weapon has been tested 7 times and is supposed to be able to travel at speeds between Mach 5 and 10 (Acton 2015). This weapon can reportedly carry a nuclear or conventional warhead. Russia's version, the WU - 14 has been developed under the clandestine project 4202 but can reportedly reach speeds of Mach 10 and will be operational between 2020 – 2025 (Acton 2015). The WU - 14 is reported to be able to reach any target with 6,200 miles within 40 minutes.

Hypersonic technology can serve many strategic purposes for a country including but not limited to countering nuclear strikes, countering anti-satellite capabilities, defense suppression, and counterterrorism (Acton 2015). The HTV and HWA can also be used as an operational ICBM making it very maneuverable but also faster than conventional weapons used today.

ICBMs currently are one of the only long-range weapon systems, capable of striking international targets. However, ICBMs are known to carry nuclear warheads and thus are highly unlikely to be deployable. Hypersonic missiles have similar range to ICBMs, but don't (yet) have a nuclear stigma and can strike targets, international or otherwise, much faster. A last consideration is the speed and stealth of the weapon; it is very hard to shoot down; missile defense technology is designed to target weapons on a ballistic trajectory. Hypersonic missiles don't follow the same trajectory as ballistic missiles, and with the exceptional speed and high degree of maneuverability, defenses against hypersonic missiles currently do not exist.

The creation and ongoing development of hypersonic missiles introduces a large unknown factor in the international community and an opportunity for change in the world's balance of power. Historically, we have seen this potential for change when nuclear weapons were developed and states were racing one another to be the leader in this new field. When nonproliferation debates came to light, there were various measures put in place in order to prevent the expansion of nuclear weapons both vertically and horizontally. In this section, we examine the historical policies put in place to prevent

proliferation of nuclear weapons and to encourage disarmament of states who had already acquired the then, new technology.

Lessons From Past Agreements

Limited Test Ban Treaty

The Test Ban Treaty of 1963 (aka Limited Test Ban Treaty or LTBT), ratified by the United States, the Soviet Union, and the United Kingdom in late 1963, forbade the testing of nuclear weapons, to exclude underground testing. The LTBT was open for signatures of other states soon after, and since its formation, 123 states have ratified the treaty and 10 others have signed the treaty but have not ratified it. This Limited Test Ban Treaty explicitly pursues a comprehensive ban on nuclear testing, banning all nuclear explosions in the air, in outer space, and in the water, but not tests underground. The ability to continue underground tests and the lessened verification methods are what sets this treaty apart from the future Comprehensive Test Ban Treaty. The LTBT was driven by two main factors: the growing public anxiety about the extent of nuclear testing and the resulting nuclear fallout; and the rising desire for slowing nuclear proliferations and the global arms race. The LTBT was one of the first forays into beginning a global community working towards nuclear disarmament and nonproliferation, and creating international norms regarding nuclear armament and use.

Non-Proliferation Treaty

The Non-Proliferation Treaty, ratified on March 5th, 1970 by the United States, Britain and Russia symbolizes the largest commitment to minimize the spread of nuclear weapons in the global community. As of today, 191 states have adhered to the treaty. The NPT also recognizes the United States, Russia, China, the United Kingdom, and France as established nuclear-weapon states. The most significant states that do not adhere to the NPT are North Korea, Israel, India, and Pakistan, 4 of those being UN member states. Since the establishment of the NPT, India, Pakistan, and North Korea have made their possession of nuclear weapons public and have continued to test nuclear devices; Israel, on the other hand, continues to remain purposefully vague on their possession or non-possession of nuclear

weapons.The NPT has 3 simple tenets: non-nuclear signatories agree to not acquire nuclear weapons, nuclear states are committed to pursue nuclear disarmament, and all states can benefit from access to peaceful nuclear technology under monitoring and other safeguards. Towards these goals, the NPT strengthened several nonproliferation international organizations, such as the Nuclear Suppliers Group and the International Atomic Energy Agency (IAEA), in their missions and the treaty is subject to being updated every 5 years in order to better address a changing nonproliferation environment. The NPT's widespread ratification helped to strengthen attitudes towards nonproliferation and disarmament, empowered global institutions and mechanisms for verification and monitoring, and build confidence and goodwill between international actors.

Comprehensive Nuclear Test Ban Treaty

The Comprehensive Test Ban Treaty is a multilateral legally binding agreement that prohibits all nuclear explosions, whether for military or civilian purposes, in any environment. The CTBT will pursue the following three goals: hinder states without a nuclear weapons program from developing one while not affecting the ability of nuclear states to maintain their existing nuclear deterrents; impede states with advanced nuclear technology from either confirming nuclear weapon designs from their past or rapidly building a nuclear weapons program; and to constrain regional arms races in areas where both horizontal and vertical proliferation have been occurring, such as through a modernization of nuclear forces in Asia. According to the United States Department of State, the CTBT is considered the final step in the non-proliferation vision of President John F. Kennedy. It was initiated by the United Nations General Assembly in 1996, however, eight states have not entered into the stage of ratification, therefore the treaty has not entered into force yet. Today, the United States is included in the eight states who have not ratified the treaty. The treaty will enter into force when all 44 states listed in Annex 2 of the treaty ratify it; these 44 states were the ones who participated in the negotiations for the CTBT between 1994 and 1996 while also possessing nuclear reactors. Of those 44 states who need to ratify the treaty for it to enter into force, only 11 states remain: China, Egypt, Iran, Israel, and the United States have signed but not ratified, and North Korea, India, and Pakistan have yet to sign. The CTBT includes the enactment of more strict

and extensive monitoring policies than the global community has seen in past treaties. While the treaty is pending complete ratification, the Comprehensive Test Ban Treaty Organization, which will be the autonomous independent organization whose mission will be to oversee the implementation of the treaty, is participating in a preparatory commission. This Preparatory Commission is in the process of creating the global monitoring network outlined in the CTBT. This network will be composed of a total of 337 potential monitoring facilities and labs around the world. As of February 27th, 2017, there are 286 fully certified facilities, 16 more installed but not certified, 17 more under construction, and 18 planned future sites.

Once the CTBT is brought to force, a Conference of the States Parties will be held ten years later in order to evaluate the effectiveness of the treaty. In order to incentivize compliance of signatories, the CTBT outlines actions taken upon any member who violates the treaty's terms. Settlements for disputes and sanctions can be implemented on the violating member, if the Conference or Executive Council determines that the situation is of great severity, they may bring the issue to the United Nations General Assembly. Informal repercussions are also implicit in the treaty. The CTBT helps establish a norm against nuclear testing in any form at any location, and signatories could face both formal and informal diplomatic backlash for any noncompliance.

Missile Technology Control Regime

The Missile Technology Control Regime (MTCR), is a non-treaty, informal community of various states who promote global non-proliferation in areas of interests such as missiles, unmanned air vehicles, and other related technologies. Although the MTCR was not officially established until April 1987, formal discussions began in the year 1983 between the states of France, Germany, Italy, the United Kingdom, and the United States. Currently, the MTCR has 34 member states, with 5 additional "unilateral adherents", including China, who are not members but have agreed to obey MTCR guidelines.

The MTCR's goal is to limit risks inherent to the proliferation of weapons of mass destruction, like nuclear weapons, chemical weapons, and biological weapons. In order to defect the proliferation of such weapons, the MTCR added controllingthe development of unmanned delivery systems. Guidelines

have been created to provide instruction of national control laws and procedures; "a two-category common control list; information-sharing on any denied cases to ensure no commercial advantage; no impediment to national space programs; presumption of denial of any transfers in terms of nuclear weapon delivery systems development; and no retransfers without authorization" (James Martin Center for Nonproliferation Studies 2016).

Because the MTCR is a non-formal agreement, it therefore has no formal mechanism to enforce compliance. The effectiveness and verification of its policies depends upon the commitment of its member states. In the past, various member states approach enforcment of the MTCR and its mission in methods distinct to each state. For example, the United States implements MTCR decisions through a sanctions law, while other states do not choose to take such a direct approach, deciding on their own enforcement system.

Mechanisms in Arms Control Agreements

Both emerging technologies and strategic weapons have been subject to arms control agreements over the past decades, and remain a policy consideration for decision makers today. Though the specific technologies subjected to arms control agreements might change, the motivations behind and mechanisms in arms control agreements haven't. Through the examination of treaties like the CTBT, LTBT, and the NPT as well as communities like the Missile Technology Control Regime (MTCR), seeing state motivations for arms control, ways to structure agreements, and various control mechanisms can be adapted to work with new, evolving technologies.

Subjecting new technologies, like hypersonic weapons, to arms control agreements can be done in a multitude of ways. Historically, the mechanisms used to limit and reduce arms, ranging from agreements of nonproliferation, limiting numbers or stockpiles of weapons, limitations on usage of the technology in specific geographic spaces, and even total bans on developing or using certain weapons in general. In the context of our case study, a multitude of mechanisms are examined, analyzed, and presented. Hypersonic weapons could be controlled using the following mechanisms: a nonproliferation

agreement, a limitation on hypersonic targeting, the integration of hypersonic missiles into the MTCR or a similarly structured organization, or a test ban on hypersonic missiles. In addition to these specific mechanisms, it is important to begin working on confidence-building measures, like risk mitigation measures, detection systems, and open communication of weapon capabilities and use in every situation regarding hypersonic technology as a foundation underlying any other agreement.

Hypersonic Nonproliferation

One of the more traditional mechanisms in arms control agreements is controlling the spread of weapons across geographic areas. Often framed in the context of nuclear technology, agreements such as the Nuclear Nonproliferation Treaty, the Outer Space Treaty, the Antarctic Treaty, and the New START include nonproliferation provisions according to the Bureau of Arms Control, Verification, and Compliance at the U.S Department of State. Within the larger context of emerging technologies, nonproliferation agreements or nonproliferation provisions within larger agreements allows for potentially dangerous technology to be contained within the states who are leading their development; typically, this happens within the larger world powers and keeps technology between peers. Nonproliferation is often talked about in two different dimensions: vertical proliferation, building more and more of a weapon within a state for a larger stockpile; and horizontal proliferation, the spread of technology and expertise from states with the ability to make the weapon in question to states lacking such ability. Technological hardware and the expertise needed to develop the specific weapon are two aspects of weapon proliferation

In the specific context of hypersonic missiles, nonproliferation would look very similar to nonproliferation agreements regarding nuclear weapons or other missile technologies. A nonproliferation agreement could be modeled after the existing NPT, where non-hypersonic states agree to not pursue the technology, and existing hypersonic states agree to keep the hardware and expertise required for hypersonic technology to themselves. Such an agreement would limit hypersonic weapons to those already in the process of developing them; which is currently limited to the United States, Russia, China, and India; and would prevent the arms race from proliferating across the globe. However, the agreement

wouldn't necessarily halt the continuing development of the weapons in the aforementioned states without additional stricter provisions. Also, states who are not currently developing hypersonic weapons but could have an interest in doing so in the future; states such as Iran, Pakistan, Japan, or South Korea; would be unlikely to join such an agreement, lacking a carrot to go with the stick. Such an agreement is essentially the strongest states outlawing anyone other than themselves from having such weapons and no stated dedication towards seeing their role reduced in the world, as have been done with nuclear weapons.

Targeting Ban

An untraditional suggestion, implementing something of a 'targeting ban' as an agreement between hypersonic states could let states continue to develop the technology, have the technology be relevant, and mitigate some of the instability that hypersonic weapons could induce. As scholars have argued, the ability of hypersonic weapons to penetrate conventional missile defense shields, and the lack of potential defensive measures against hypersonic missiles, the successful development and potential deployment of these weapons could contribute to destabilization (Acton 2015; Zhao 2015; Gubrud 2015; Nagappa 2015). Much of these concerns stem from the potential of hypersonic weapons to be used to target an adversary's nuclear forces; Russia has particularly been concerned with the potential of hypersonic weapons to knock out nuclear forces without having the ability to stop it (Acton 2016); in addition, in his 2016 Worldwide Threat Assessment given to the United States Senate Armed Services Committee, James Clapper stated that ""strategic non-nuclear precision weapons" was one of the "main external military threats to the Russian Federation".

A multilateral agreement between states regarding limitations on targets or missions that hypersonic weapons are not permitted to be arrayed against would, theoretically, allow for the destabilizing aspects of the weapon to be mitigated. If states were party to an agreement that hypersonic weapons were not permitted to be targeting nuclear forces, and perhaps other sites under missile defense shields, dynamics could remain stable. However, this would likely cripple the effectiveness of the weapon system, and would represent a large amount of money spent on research and development for a weapon which, while developing technology and perhaps leading to cutting-edge inventions on the civilian side, is

a fancier and much more expensive model of weapons we already have. The capabilities that make hypersonic missiles so desirable are the speed at which they travel and their maneuverability; able to penetrate missile defense shields, making them useful to the Conventional Prompt Global Strike (CPGS) ability the United States is pursuing. Taking away those capabilities through an agreement, limiting targeting options, make it unlikely that hypersonic weapons will contribute to the CPGS mission as meaningfully as they originally intended to.

Missile Technology Control Regime Integration

The MTCR, as explored above, exists as an informal collection of states agreeing to a common set of norms and guidelines regarding nonproliferation of missile technology. The MTCR's stated goal is protection against the inherent risks of weapons of mass destruction, hypersonic missiles could serve as vehicles for nuclear warheads of a respectable payload (Acton 2015). Hypersonic missiles are being seen as a useable long-distance precision missile with a conventional payload, unlike ICBMs. However, the possibility of hypersonic missiles being outfitted with nuclear warheads represents a potential uncertainty as to what the missile is carrying and thus carries an extreme inherent risk, akin to the deployment of an ICBM. The MTCR has a demonstrated ability to add new weapon systems to its responsibilities, i.e. the addition of unmanned aerial vehicles. Adding hypersonic weapons to its responsibilities is a possible control mechanism.

However, the effectiveness of this mechanism is hard to determine. With the MTCR not being a legally-binding organization, acting not as a unified authoritative body but as an informal community, compliance would be in the hands of member states individually. It could also prove difficult to have states in the MTCR agree to expanding their responsibilities to hypersonic weapons if the political will of said states is low, but with the MTCR being an informal community, enforcing the guidelines might not be a large challenge since states are invested in them simply through voluntarily joining the organization. Because of this, member states who are already invested in the MTCR, and its guidelines, could be as invested in controlling the export of hypersonic weapons as they are currently in controlling ballistic weapons.

Hypersonic Test Ban

A more traditional control mechanism, test bans have been a central piece of arms control agreements, and is the mechanism advocated for in this paper. The Comprehensive Test Ban Treaty and its organization, alongside the NPT, form the central pillars of the international nonproliferation regime. Test bans outlaw the testing of weapons or the technology associated with them. The CTBT, if brought into force, would outlaw the detonation of nuclear bombs as testing. These bans essentially kill development of the weapon or technology; while it is possible for states to continue building weapon without conducting tests, it is very unlikely such a weapon would ever be brought into a state's military doctrine or force posture. Without extensive testing, newly developed technologies are too risky to be deployed in theatre; even fully-developed and fully-tested strategic weapons have maintenance issues and chances for accidents through organizational and command/control issues. An untested weapon exacerbates those issues, and adds a plethora of unknown variables that could go disastrously wrong. While being theoretically viable, using a wholly untested technology is very unlikely to occur, given how much the burden outweighs the benefits of the weapon, thus test bans can effectively end arms races and provide very strong safeguards against proliferation.

In the context of implementing an arms control agreement concerning hypersonic technology, a test ban agreement would theoretically provide the best mechanism for control. With the goals of arms control being to stop a costly arms race and reduce insecurity, banning the testing of hypersonic missiles would help maintain the current status quo, but still leave the potential for other forms of technology to contribute to the CPGS doctrine. A test ban has 3 main strengths: it is easily verifiable, it is very strong arms control, and the technical aspects are easily negotiable. Testing hypersonic weapons is possible in labs or wind tunnels, but fully-testing the missile under realistic conditions requires realistic open-air simulations. These realistic tests would expose the test to a plethora of sensors in space, sea, and land, and also runs the (admittedly slight) possibility of ordinary people capturing images or footage of the test on social media. The test ban is also strong arms control, as it would likely lead to no hypersonic missiles becoming deployable assets in any military, as no state is likely to deploy untested weapons (Gubrud

2015). Finally, the technical aspects of the missile can be easily defined; negotiations could target the maneuverability technology of the missile, could target the trajectory the missile takes, target the technology allowing it to go at speeds of Mach 5 through Mach 12, or a variety of other technical aspects.

However, the impact of the political will of individual states on outcomes of arms control agreements is very high. With at least four states having been developing hypersonic weapons, it could be difficult to have states willingly give up that development if hypersonic weapons are viewed as an absolutely critical asset for their future security. However, the possibility that other states continue development mostly due to not being able to afford falling behind its peers who are developing the technology is also likely. If the motivation is simply to keep up with your peers, it is likely easier to enter into an arms control agreement. Regardless of specific arms control agreements or mechanisms, developing confidence-building measures with other states similar to those in place for ballistic missiles should be done, even if not implemented. These confidence-building measures would allow for more stability if an agreement fails or never solidifies, and allows the possession of new strategic weaponry without an unchecked escalatory risk existing.

Issues in Verifying Compliance

The recent developments in the field of hypersonic missile technology will likely warrant renewed efforts towards multilateral arms-control negotiations, specifically between the U.S., Russia, and China. Given the present climate of mistrust between the world's superpowers, it is imperative that compliance with the terms of any new arms control agreements be unilaterally verifiable by each side. Verification requires that each nation have a reliable and objective means of monitoring the military activities of the other. Accordingly, most developed nations have continued to maintain a litany of methods for gathering such information from a distance. These methods are collectively referred to as national technical means of verification.

The issue of verification is quite separate not only from the legal question of whether an observed activity constitutes a treaty violation but also from the political question of what to do about a violation once it has been detected. Nevertheless, verification is more than just a technical issue. In the U.S., for

instance, verification has been a focal point of the recurrent political debate over the merits of various existing and proposed arms-control treaties. Opponents of arms control efforts have often argued that the U.S. cannot verify compliance of parties to any agreement well enough to maintain national security under the agreed upon terms, whereas proponents of arms control tend to argue that the U.S. should still make efforts to comply in a show of goodwill. In general the question of whether or not a treaty is verifiable by the U.S. can be reduced to two narrower questions. First, at what level of clandestine weapons development activity by other actors would U.S. security be jeopardized? Second, is the U.S. system of verification capable of detecting that level of activity?

When considering the development of hypersonic propulsion technology, especially at the prototype stage, it is our position that any level of clandestine development by other actors outside of the laboratory setting would jeopardize our national security. However, the same systems that the U.S. used to monitor Soviet/Russian ICBM tests would also likely be able detect these efforts. Exploiting HUMINT sources has been a successful method of detecting weapons development at the laboratory stage in the past. Once these weapons exit the laboratory stage, satellite reconnaissance can collect data on hypersonic weapons tests that include heat signatures, electromagnetic readings, and acoustics. This was the U.S. strategy for detecting Soviet/Russian nuclear weapons development, and we assess that the same model would also be effective in detecting hypersonic weapons development. At the very least, we would be able to identify and react to instances of noncompliance regarding any arms control measures for these new weapons.

Putting Compliance Problems in Perspective

Historically, bilateral nuclear arms control negotiations have labored under a burden of suspicion. Even on issues in which there was a perceived mutual interest, such as the control of nuclear weapons, U.S. skepticism of bilateral partners and vice versa have been constant elements of existing arms control treaties. While some resistance to the idea of negotiating arms control agreements with adversaries lies in the foundation of American politics, inevitable concerns regarding the secrecy of our

adversaries' (and at times allies') motives can seemingly make every violation of compliance seem incredibly dangerous.

However, all compliance problems are not of equal consequence. Although we may attribute considerable significance to a noncompliant act simply because it occurs, informed policy judgments require a sense of what the other side gains, or what we lose, as a result of a given action. Agreements, after all, do not exist in a vacuum; they exist to protect or advance national interests. In particular, we need to know how an action affects the overall balance of burdens and benefits embodied in an agreement in order to fashion an appropriate response. In a report released by the Carnegie Endowment regarding the SALT II treaty, a panel of experts stated "A broad variety of responses are possible. It is by no means automatic that a violation leads to abrogation or a U.S. military response. An arms control agreement between adversaries is a dynamic process and, in every condition, our objective will be to prevent Soviet advantage while, in most situations, also seeking to preserve the basic agreement." They essentially concluded that not every instance of noncompliance threatens national security, and retaining the agreement while also justifying our own deviations from it don't mutually exclude one another.

How, then, should we assess the significance of compliance problems? Domestic debates about these issues have focused mainly on the fact of alleged violations and the wisdom of making them public. What of their impact on American security and the arms control process? In making assessments of compliance issues, it makes sense to utilize two methods of assessment:

The first, political criteria, attempts to capture the significance of problems for the workings of the treaty regime. We are concerned with the following issues:

1. Does an action violate agreed treaty language? If not, does it create tension between different interpretations of obligations (and, if so, what does this suggest about the way the treaty was negotiated)?
2. Does an action, even one that does not breach treaty language, alter or disappoint U.S. expectations of what was precluded or allowed under the terms of an agreement? If so, were such expectations realistic?

3. How does the other side's conduct affect formal or informal rules for verifying the agreement or for resolving disputes over compliance?
4. In general, what does an action suggest, if anything, about our adversaries' motives?

The significance of compliance problems should also be measured by the application of strategic criteria. These attempt to capture the security implications of specific actions for the United States. Here, the major issues are:

1. Does a violation or an ambiguous action contribute to the other side's military capacity or alter the military balance in a disadvantageous way?
2. Does an action, even if not clearly a violation, reduce the cost of the other side's ability to abandon the agreement on short notice?
3. Does an action undermine the predictability or transparency of the military balance that a particular agreement was meant to codify?

While compliance problems may have diverse consequences, they also vary according to type. It is misleading to think of "compliance problems" solely as prima facie breaches of treaty language. Violations may be only a small set of the universe of all possible problems, including, for example, ambiguous actions that edge close to a prohibited activity or actions that, while not banned, raise the possibility of circumvention. Indeed, if we conceived of compliance problems only in legal terms, we might exaggerate the value of a small unintentional violation or, conversely, overlook the importance of an action that, although exempted from restriction, could increase the other side's capacity to "break-out" of an agreement on short notice. Both are types of compliance problems, but only the former (and the less significant) example is a violation.

Conclusion

Looking to the future of arms control, we conclude that not much has changed in the way states think about arms control nor in the mechanics of arms control; the methods that were used in the past still have relevance to the future. Using hypersonic weapons technology as a case study, relevant existing

agreements were analyzed and potential ways for controlling hypersonic weapons explored. While specific ways of coming to an agreement over hypersonic weapons is still complex and likely yet to be solved, the ability for already known and used mechanisms and compliance methods to address hypersonic technology illuminates how arms control could remain the same in the future as it is today. Arms control is likely to be just as, if not more important, in the world of future weapons as it is today; as Mark Gubrud puts it, "Sources of this resurgent danger include smoldering geopolitical rivalries, shifts in economic power, and new weapons made possible by emerging technology. The world has failed so far to put the nuclear genie back in the bottle, and new genies are now getting loose" (Gubrud 2015). But that future can be addressed much as it has in the past, with a multitude of states coming together in diplomatic negotiations working to provide a more stable security environment by reducing ambiguity, eliminating inherently destabilizing weapons, and establishing confidence-building measures.

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