Understanding the Current and Future Impacts of Hypersonic Weapons Development on International Relations and Politics

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

In recent years, hypersonic technology has become a matter of huge importance to the whole of society. Due to its potential use as a seemingly unbeatable weapon, many nations have invested significantly in furthering the development of these technologies. Similar to the nuclear arms race, opposing nations have been taking huge steps to create hypersonic weapons which would have the ability to counteract those developed by their enemies. At the same time, it can also be demonstrated that this increased interest in hypersonic technology did not originate just from an isolated political system, but also from the sheer existence of the technology itself. Using Actor Network Theory (ANT), this Science, Technology, and Society (STS) thesis ultimately aims to understand how this escalation in hypersonic weapons development has occurred and the ways it has impacted political decisions and society at large. Additionally, from this analysis, this thesis will provide possible solutions aiming to de-escalate these tensions created by hypersonic weapons.

STS Framework

The primary theory which will be used to analyze this topic is known as Actor Network Theory (ANT). Essentially, ANT is a framework which aims to describe any social issue as a network of actors which interact with each other (Nickerson, 2022). These actors can be human actors, such as politicians, government institutions, or citizens for example, or they can be non-human entities, such as weapons, vehicles, or other forms of technology (Nickerson, 2022). All of these actors affect and impact each other through an interconnected network (Mol, 2010 p. 258). When analyzing how these actors interact with each other, it is important to only consider the effects these agents have on each other and not their goals or ends (Mol, 2010 p. 255). Essentially, ANT is a method of documenting a social system and its components, not a framework which determines the intentions of the actors (Mol, 2010 p 255.) Also, all of the actors in the system are given equal significance in the analysis (Nickerson, 2022). A non-human actor, such as a piece of technology, is documented in this network in the exact same way as a human actor and is considered to be just as important (Nickerson, 2022).

ANT is an ideal method of describing how hypersonic weapons affect political decisions and interactions between nations. Since ANT is very effective at connecting the effects of human and non-human entities, this framework will be able to show how inanimate hypersonic weapons actually affect and impact political institutions, militaries, social groups, and organizations. Treating these weapons as equally important actors to these human institutions will prevent the significance of this technology's existence on the rest of society from being overlooked. Also, due to the complex nature of large political institutions and nations in general, purely looking at the effects which these actors have on each other and treating them as "black boxes" will simplify the analysis significantly (Nickerson, 2022). Observing this network of causality will also aid in determining what additional actors or modifications to the actors can be made to achieve a desirable future outcome.

Background and History on Hypersonics

Before actually analyzing how hypersonic weapons have impacted the world on a global scale, the nature and history of hypersonic technology must first be understood. Hypersonic technology is defined as "aircraft, missiles, rockets, and spacecraft that can reach speeds through the atmosphere faster than Mach 5" (Wilson, 2019). This is generally around 3,500 miles per hour, or one mile per second (National Security Technology Acceleration, 2022). Unlike the supersonic regime, which is just faster than the speed of sound, the hypersonic regime is significant because the speeds are large enough to heat up the air surrounding a body to the point that plasma is generated (National Security Technology Acceleration, 2022). Because the chemistry and aerodynamic characteristics of plasma are much different than that of regular air, this significantly affects the pressure, density, and temperature of the fluid surrounding the traveling body (National Security Technology Acceleration, 2022). Therefore, designing aerodynamic bodies which are optimized to function in the hypersonic regime and withstand the temperatures generated by hypersonic flight is a very difficult engineering challenge to solve.

Even though hypersonic technology has only received significant notoriety in the realm of national security in recent years, it has been in existence for several decades. The first hypersonic vehicle ever created was the German V-2 rocket first launched in 1944 (Atherton, 2022). This was a ballistic missile used during World War II on England, and it was able to reach speeds in excess of mach 5 while descending upon its targets (Atherton, 2022). The bumper 5, a rocket which used the same base as the V-2, was the first vehicle to achieve hypersonic speeds upon ascent (Atherton, 2022). This eventually led to the development of the liquid fueled Atlas intercontinental ballistic missile (ICBM) in the 1950s by the US Air Force, which was one of the first of its kind able to carry nuclear payloads at a range in excess of 5,000 miles (Heppenheimer, 2007 p. 49). The Atlas was succeeded by other ICBMs, such as the Minuteman ICBM, which is still used by the US today as a nuclear deterrent (Atherton, 2022). Although all of these missiles fly at hypersonic speeds at some point in their trajectory, they all reach their targets by being launched into space and reentering the atmosphere at their target using non air breathing propulsion systems (Heppenheimer, 2007 p. 1-200). These weapons are different from the air breathing/low altitude missiles which modern policy makers traditionally refer to as “hypersonic weapons” (Atherton, 2022). For simplicity, “hypersonic” weapons or technology will refer primarily to atmospheric based or air breathing hypersonic systems in this thesis.

After the creation of these orbital hypersonic weapons, engineers and scientists began developing prototypes for lower altitude hypersonic vehicles. In the 1950s, the Air Force began developing the Navajo and Bomarc missiles, which were air-breathing supersonic missiles that used ramjets to accelerate them up to Mach 3 (Heppenheimer, 2007 p. 197). These ramjet engines could theoretically operate in low hypersonic conditions above Mach 5 (Hall, 2021). The X-15 was created shortly after, an experimental aircraft built to test the feasibility of a hypersonic vehicle which could fly in the atmosphere (National Security Technology Acceleration, 2022). Although this aircraft used non air breathing liquid fuel engines, it was able to maneuver during atmospheric flight using aerodynamic control surfaces (National Security Technology Acceleration, 2022). In fact, at a relatively low altitude of just 102,100 feet, the X-15 was able to set a world speed record of Mach 6.7, or 4,520 miles per hour (Wilson, 2019). However, both of these atmosphere based hypersonic projects were halted due to a lack of interest from the military. The US Air Force concluded that the Titan III and Minuteman ICBMs were operationally more successful than the Navajo and Bomarc ramjet missiles as a nuclear deterrent (Heppenheimer, 2007 p. 201). Also, the X-15 project was ended due to a lack of "national interest" and supporting technology (Wilson, 2019).

However, even though research on hypersonic weapons technology was temporarily halted, the development of this technology began again in the 21st century. Especially as computational testing technology and temperature resistant materials improved, developing atmosphere based hypersonic systems became a much more cost effective process than in the mid 20th century (Wilson, 2022). In a rare cooperation, both the US and Russia engineered and tested a scramjet powered rocket in 1998, another air breathing propulsion system which is able to operate more efficiently in high hypersonic conditions (Atherton, 2022). This rocket was able to reach a speed of mach 6.5 in the atmosphere, far above the minimum threshold of mach 5 (Atherton, 2022). However, this cooperation was short-lived. Nations such as the US, China, and Russia began conducting significantly more tests to develop air breathing hypersonic weapons. In 2010, the US was able to successfully test the X-51 waverider, a scramjet powered hypersonic missile which could reach speeds of at least Mach 5 (Atherton, 2022). However, due to an even larger allocation of resources to hypersonic weapons development, Russia and China have reportedly been able to surpass the efforts of the US in this field. For instance, in 2018, China announced they were constructing an 870 foot wind tunnel capable of simulating speeds from Mach 10 to 25, whereas the US only had a smaller tunnel capable of producing speeds from only Mach 5 to 9 (Wilson, 2019). Also, in the same year, Russia reported the testing of their Kinzhal missile, which was stated to be able to travel at speeds of up to Mach 10 (Wilson, 2019). This triggered a race to create hypersonic weapons between these opposing nations.

Analysis of the Social Effects

From this background and additional context, many connections can be drawn between hypersonic weapons development and political and social activity. Using ANT, both human and non-human actors can be connected to understand the escalation of hypersonic weapons development and tensions. Firstly, the major political actors should be defined, which are the primary entities which make political decisions on behalf of a nation of people. For the sake of simplicity, this analysis will mainly consider the US, Russian, and Chinese governments and their corresponding militaries as major political actors. However, other smaller political actors will be considered later on that are directly impacted by the existence of these weapons, such as

Ukraine. Additionally, all of these political actors are accountable in some manner to their citizens. There are also many significant non-human actors which directly impact these human ones. The most obvious of these non-human actors would be the hypersonic weapons themselves, as this is the technology that is mainly in question. However, there are also other technologies which play a significant role in this network. For instance, nuclear weapons, ICBM technology, and anti air missile systems also play a large role in how this network behaves. Also, simpler subsystem technologies, such as computerized aerodynamic and thermal testing, thermal resistant materials, and more advanced air breathing propulsion systems must be considered.

Now that the actors have been defined, the complex network between all of these nodes must be laid out. Firstly, at its core, what makes hypersonic technology such a large concern for so many nations is that it is an effective method of delivering nuclear payloads to enemy targets. Looking at the United States specifically, one of the reasons the nation invested so heavily in developing ICBMs such as the Atlas, Titan III, and Minuteman rockets was because they were able to strike targets with nuclear weapons over very large ranges in a very short amount of time (Heppenheimer, 2007 p. 1-200). As a result, this naturally warranted a response from other nations at the time, especially the Soviet Union, to create their own ICBMs which have similar capabilities in order to act as a deterrent. As time progressed, the US made further strides to develop atmosphere based hypersonic systems such as the Navaho and Bomarc ramjet missiles and the X-15 due to the potential these prototypes had to lead to more strategically advantageous methods of delivering nuclear payloads. However, these prototypes did not have the same range or speed as traditional ICBMs, as the computerized thermal and aerodynamic testing, thermal resistant materials, and air breathing propulsion technology was not advanced enough to allow these devices to perform at a sufficient level (Wilson, 2019). As a result, the US, as well as other nuclear enabled nations, focused on developing and producing traditional ICBMs.

However, at the turn of the 21st century, two major changes occurred. Firstly, significant strides were made in the improvement of computerized thermal and aerodynamic testing, thermal resistant materials, and air breathing propulsion technology, meaning that air breathing and atmosphere based hypersonic systems could be developed more efficiently (Wilson, 2019). Also, following the withdrawal of the US from the Anti-Ballistic Missile Treaty in 2001, the Russian and Chinese governments became more concerned that the US government would gain a tactical advantage over them by improving ICBMs and producing more of them (Sayler, 2022). These governments were also concerned that their traditional ICBMs would simply be intercepted and destroyed by improved US missile defense systems (Sayler, 2022). This is what encouraged the Russian and Chinese governments to invest so heavily in hypersonic technology in the early 2000s. The political decisions of the US as well as the sheer existence of newer technologies were actions which ultimately led the Russian and Chinese governments to respond.

It is important to understand why the Chinese and Russian governments chose to invest in atmosphere based hypersonic technology over regular ICBMs as a response to the US government. Unlike traditional ICBMs, air breathing or atmosphere based hypersonic weapons are not easily detectable by traditional radar because they do not follow a high altitude arc trajectory (Sayler, 2022). This means that if a hypersonic missile was sent to strike a target, the US military would not be able to respond to the threat in time in order to neutralize it (Sayler, 2022). Also, air breathing hypersonic weapons are able to maneuver and change their trajectory, making them significantly harder to neutralize using anti missile defense systems (Sayler, 2022). This would also make a hypersonic missile harder to neutralize since its path and final destination are unpredictable (Sayler, 2022). In addition to the fact that these weapons can potentially carry nuclear payloads, these reasons made the existence of these types of hypersonic weapons an inherent threat to US national security.

Similar to the nuclear arms race, the US naturally responded to the existence of Russian and Chinese hypersonic weapons development by performing their own research. Since hypersonic weapons by their very nature pose a threat, the US reacted to these weapons by working on projects such as the X-51 Waverider (Atherton, 2022). However, because the Russian and Chinese governments prioritized hypersonics research before the US government, Russian and Chinese hypersonic weapons performed at a higher level than US ones (Wilson, 2019). This can be seen in the Russian Kinzhal missile, which underwent tests in 2018 (Wilson, 2019). This visible gap in hypersonic weapons knowledge between the US and China and Russia, exacerbated by the fact that these weapons could potentially carry nuclear payloads, caused the US to spend even more money on hypersonics research in the late 2010s. In 2019, for example, congress raised the budget devoted towards hypersonics research from $100 million to $250 million (Wilson, 2019). In 2022, this budget went up to $2.3 billion (Sayler, 2022). This budget is being directed towards multiple new hypersonic military projects still under development, such as Conventional Prompt Strike Missile or the Long Range Hypersonic Weapon (Sayler, 2022).

At first, the hypersonics weapons race may appear as simply an isolated tactical battle between political systems and their militaries. However, the development of these weapons has also begun to impact the lives of the ordinary civilians living within these nations in recent years. For example, in 2022 to 2023, Russia used the Kinzhal hypersonic missile in its attacks on Ukraine for the first time (Neuman, 2023). Although only conventionally armed (not carrying a nuclear payload), Ukrainian air defense stated they did not have the technological capabilities to shoot these missiles down, even though Ukraine could neutralize most traditional missiles in the past (Neuman, 2023). Some of these attacks were not just on military targets, but civilian ones as well (Neuman, 2023). In addition to these conventional attacks, simply using these missiles in any regard could lead to an increased chance of nuclear conflict. Because hypersonic missiles have the ability to carry nuclear payloads, any use of a hypersonic missile could potentially escalate into a nuclear response even if the missile is conventionally armed (because there is no way to assess whether the missile contains a nuclear warhead during flight) (Sayler, 2022). This escalation could turn an isolated arms race into a nuclear conflict which could potentially kill millions of uninvolved civilians.

The Way Forward

From this analysis of the progression of hypersonic weapons development and its effects, many possible solutions can be discussed to mitigate the negative effects of such advancements. Firstly, due to the inherent danger that hypersonic weapons pose in their ability to carry nuclear weapons, these types of weapons could be treated in a similar manner to that of traditional nuclear weapons. For instance, current nations which possess hypersonic weapons could organize a treaty which limits the use of these munitions in scenarios which could be interpreted as nuclear attacks. This would ultimately allow hypersonic weapons to still be used and developed, but it would prevent them from being used in a way which could trigger a nuclear response. If a multinational treaty cannot be organized, the US government in particular could make strides to increase funding for the development and production of hypersonic weapons. Although this escalation of development might build tension between nations, it would ultimately act as a deterrent which would discourage the weapons from being used with nuclear warheads completely (Hallion, Bedke, & Schanz, 2016). Also, these hypersonic weapons should only be used with conventional munitions in circumstances which would not be interpreted as a nuclear attack.

One might argue that trying to increase the development of hypersonic weapons would actually make this conflict worse and could actually increase the chances of engaging in a nuclear war. However, if one nation or political interest possesses more hypersonic weapons than the other, there will be much less of a deterrent for that nation to use their weapons with nuclear payloads because the opposing nation would not be able to launch an effective counterattack. Therefore, developing hypersonic capabilities which match that of opposing nations actually makes a nuclear conflict less likely. Additionally, if hypersonic weapons technology is further developed and explored, the resulting advancement could be used to contribute to non-military hypersonic projects. For example, the same technology used to create hypersonic missiles could be implemented into hypersonic cargo or passenger vehicles. This could benefit society greatly in advancing aerial transportation.

Conclusion

Hypersonic weapons have garnered a lot of attention in recent years. Not only has the development of these weapons increased significantly, but they have also been used in real combat and have made a visible impact on people's lives. This was the result of not an isolated attempt to develop this technology, but decades of technological advancement and changes to the political landscape. If decisions are made carefully, the destruction which these weapons have the potential to cause can be minimized, and the world can hopefully become more peaceful

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