# The Socio-Political Impact on the Development of Hypersonic Technology

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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

The steady march of technological progress regarding hypersonic technology and its development throughout history has been achieved through various driving forces such as competition, national security, public opinion, and international collaboration. Andy Hargreaves states that “Implementation of technological change must involve critics as well as advocates." This encapsulates the trajectory of technological advancement, emphasizing its relentless march forward regardless of the opposing or supportive factors at play. This brings into question what exactly those factors are, and leads to the main point of this research paper: determining the socio-political impact on the development of hypersonic technology both historically and in the present day. This important point is analyzed using the Social Construction of Technology (SCOT) STS framework. This paper aims to help better understand the history behind hypersonic technological development and to determine its influence on countries such as the United States, China, and Russia.

## Research Question and Methods

The research question answered in this paper is: What are the socio-political impacts on the development of hypersonic technology? By analyzing this question, the goal is to enhance the understanding of the complex interactions between the development of hypersonic technology, society, and politics. The methods utilized to answer the research question consist of a literature review, historical analysis, and case studies of specific technologies or programs. The information is presented primarily in a chronological approach to trace the historical development of hypersonic technology and identify its socio-political impacts over time. Keywords that encapsulate the essence of this paper include Hypersonics, Social Construction of Technology, Socio-Political Impact, Competition, and Collaboration. The remainder of the paper

will consist of a background on hypersonic technology, relating its development to the SCOT STS framework, results and discussion, a historical chronological analysis, limitations of the research paper, considerations for future research, and concluding remarks.

## Background

The relevance of Hypersonic Technology in today's world has surged, especially in the realm of National Security and Defense. But what is Hypersonic Technology? Hypersonic flight is defined as exceeding Mach 5, or 5 times the speed of sound (John Anderson, 2012). This is typically around 3,500 miles per hour, or one mile per second (National Security Technology Acceleration, 2022). Technology utilizing this characteristic has both civilian and military applications, consisting of things such as spacecraft propulsion, commercial aviation, military missiles, and more. Hypersonic technology offers several advantages such as rapid response, enhanced maneuverability, and quick travel times. On the other hand, developing safe and reliable hypersonic technology poses significant engineering challenges such as mitigating extreme temperatures and ensuring stable flight control. Unlike supersonic flight, hypersonic flight 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). Hypersonic technology must be able to function under these conditions, which has proved both difficult and costly.

Though the interest in hypersonic technological development has peaked in recent years, the technology has existed for many years. The first vehicle to achieve hypersonic speeds was the German V-2 rocket, which cleared Mach 5 as they descended and struck targets in England during the late stages of World War 2 (Atherton, 2022). Using much of the same technology as the V-2 rocket, the first ever fully (both ascending and descending) hypersonic capable vehicle

was the Bumper 5 rocket, launched in 1949 by the United States at White Sands proving ground (Anderson, 2012). This eventually led to the first intercontinental ballistic missile being fielded by the United States 10 years later, called the Atlas rocket. Since then, various other hypersonic platforms have been developed including the X-15 and the X-43 that have proven the increased knowledge and capability of hypersonic technology.


Figure 1: X-15 (Aerotech News, 2021)

Figure 2: X-43 (Anderson, 2012)

In today's world, there is fierce competition brought upon by entities trying to navigate these challenges, and this has led to a new international race towards rapid development of hypersonic technology. Any collaboration between countries such as the United States, Russia, and China has been hindered because of this, and has thus led to technological imbalances which further strain relations. The United States currently lacks the rumored capability of both China and Russia regarding hypersonic technology due to a smaller allocation of resources in recent years. Despite this, the United States has slowly ramped up the research and development of hypersonic technology and has begun testing new technologies such as the X-51.

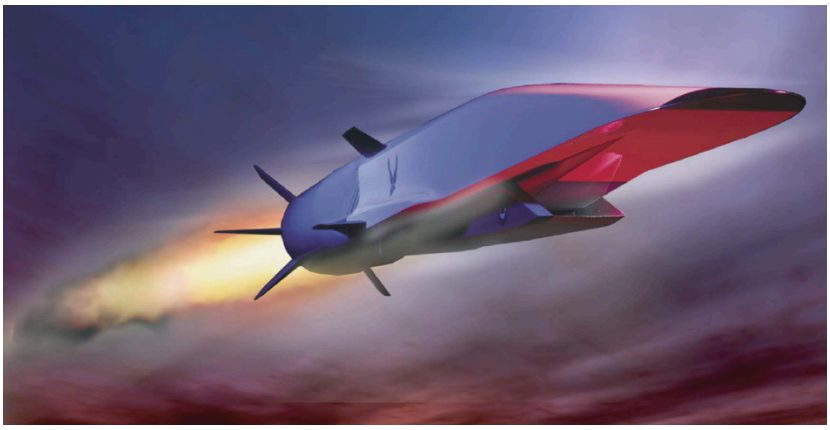

Figure 3: X-51A Waverider (USAF, UVA Article, 2022)

## Social Construction of Technology and Hypersonics

As previously mentioned, the primary theory utilized in this paper to analyze the topic is called the Social Construction of Technology (SCOT). SCOT is a theory within the field of STS, and argues that technology does not determine human action, but rather human action shapes technology. SCOT also details that the ways a technology is used cannot be understood without understanding how that technology is embedded in its social context (Klett, 2018). Hypersonic technology sits at the intersection of STS because it is shaping and being shaped by advances in these domains. Considering things such as scientific exploration and research, national security and defense, societal impacts, ethical considerations, economic challenges, international collaboration, and competition are why examining this topic is so relevant to STS. Essentially, the SCOT framework is used to provide an understanding of how technological development is shaped by social forces, which include interests, values, beliefs, and stakeholders. Applying SCOT to examine the development of hypersonic technology involves analyzing how social factors influence the design, development, and implementation of hypersonic technology.

SCOT is not only a theory, but also a methodology: it formalizes the steps and principles to flow when one wants to analyze the causes of technological failures or successes (Klett,

2018). For this reason, the development of hypersonic technology is analyzed in a way that shows whether the progression of this technology, along with the points of stagnation, are attributed to social and political factors. SCOT is an ideal method of describing how both societal values and political decisions affect the development of hypersonic technology. Treating the development of this technology as a construct of both social and political decisions helps to better understand the possible impact of this technology and creates a significant weight to its existence. This objective is done by identifying relevant social groups as well as outlining problems and conflicts throughout hypersonic technologies' historical timeline.

## Results and Discussion

The historical development of hypersonic technology has been profoundly influenced by many socio-political factors, spanning through World War II and the Cold War Era, all the way to the present day. The socio-political impacts that have shaped the trajectory of hypersonic technology are highlighted in its evolution from a military imperative to a focal point of contemporary geopolitical competition. Hypersonic research evolved with changing geopolitical landscapes and technological advancements, leading to many different applications. In the 21st century, hypersonic technology has emerged as a focal point for strategic competition between countries like the United States, China, and Russia, all vying for technological supremacy and geopolitical advantage. Emphasizing the role of social groups, power dynamics, and interpretative flexibility in shaping technological trajectories, the development of hypersonic technology through the lens of the Social Construction of Technology (SCOT) framework offers valuable insights and context into what social forces are at play.

One significant socio-political impact of hypersonic technology development is its role in military strategy and national security. Historically, hypersonic capabilities have been sought

after by military powers due to the potential to revolutionize warfare. Hypersonic technology has been framed as strategic assets capable of unprecedented precision, speed, and range. Furthermore, the development of hypersonic technology has spurred international cooperation and competition, reflecting broad geopolitical dynamics. While collaborative efforts have been observed among allies and partners such as joint research and technology-sharing agreements, hypersonic capabilities have also fueled intense rivalries between major powers. This pursuit of hypersonic technology has sparked concerns about arms races, destabilization, and strategic erosion. Hypersonic technology has thus been used as a tool for deterrence, a means of power projection, global security, diplomatic negotiations, arms control efforts, and alliance dynamics.

Additionally, the commercialization of hypersonic technology for space exploration, transportation, and telecommunications has the potential to generate economic growth and technological innovation but also raises questions about access and equity. Ethical dilemmas naturally emerge from the dual-use nature of hypersonic technologies, with implications for arms proliferation, human rights, and international law. Applying SCOT determines how different social groups such as policymakers, scientists and industry stakeholders negotiate competing values, interests, and interpretations in shaping the governance of hypersonic technology. Examining these impacts allows insight to be gained into the complexities between technology and society, highlighting the importance of understanding the socio-political context in shaping technological trajectories and governance frameworks.

## Chronological Analysis

This portion of the results and discussion section details the historical timeline of hypersonic technology development and its social construction by utilizing chronological analysis. Through the use of historical analysis, insights are gained relating to the complex

interplay between technology and society, highlighting the enduring significance of hypersonic technology in shaping global security, innovation, and international relations.

**World War II – 1940s**

The primary social groups that defined this period were military and defense agencies, as well as the general public. The first developments made with regards to hypersonic technology were done by the Germans, during the late stages of World War II in the form of the V-2 Rocket. Any ballistic missile with a range greater than 400 km operates at hypersonic speeds, so hypersonic systems have flown since the use of V-2 rockets during World War II (Van Wie, 2021). Through the efforts of scientists led by Werner von Braun, it was first successfully launched on October 3, 1942, and was fired against Paris on September 6, 1944. Two days later the first of more than 1,100 V-2s was fired against Great Britain (Britannica, 2024).

Figure 4: V-2 Rocket (V2 Rocket History, 2018)

Driven by Nazi Germany's ambitions for advanced military technology, the V-2 rocket reflected Germany's efforts to develop strategic weapons capable of unprecedented speed and range. The intense competition among global powers fueled interest in innovative technologies like the V-2.

**Cold War – 1950s**

After the war, both the United States and the Soviet Union captured large numbers of V-2s and used them in research that led to the development of their missile and space exploration programs (Britannica, 2024). During this early Cold War period, the United States and the Soviet Union engaged in a race for technological superiority, driven by geopolitical tensions and ideological rivalries. Aerospace engineers and scientists, especially former Nazis, defined the primary social groups in this period. The Soviet Union went on to develop a variety of sounding rockets and missiles based on the V-2, where they gradually increased their capabilities. From 1954 to 1957, Soviet rocket designer Sergei Korolev headed the development of the R-7, the world's first ICBM (intercontinental ballistic missile). Flight tested in August 1957, the R-7 was powerful enough to launch a nuclear warhead against the United States, as well as launch spacecraft into orbit (National Air and Space Museum, 2023). On October 4, 1957, the R-7 rocket launched Sputnik, shocking the world and beginning the space age. America followed suit on January 31, 1958, with the launch of Explorer 1 aboard an Army Jupiter-C rocket, which was a modified Redstone ballistic missile. The experimental research into hypersonic flight by both superpowers was motivated by military imperatives, with a focus on developing capabilities for strategic reconnaissance, missile defense, and space exploration. The social and political dynamics of the Cold War era fueled investments in hypersonic technology as a means of achieving military dominance and national prestige.

**Cold War – 1960s**

The development of hypersonic technology continued to expand in the 1960s and reflected both the Soviet Union and the United States' commitment to pushing the boundaries of technology during the space race. Space agencies and the cold war rivalry were the dominant

social factors/groups at play during this period. One prominent example of pushing previously unimaginable boundaries is the X-15 program pioneered by the United States. On October 15, 1958, the first X-15 hypersonic rocket-powered aircraft rolled out of its factory (Uri, 2023). The X-15 reached speeds exceeding Mach 6, and altitudes of over 100km. These flights provided invaluable data on aerodynamics, thermal protection, and human factors in hypersonic flight, and influenced the development of future programs such as the space shuttle. Additionally, the 1960s marked the start of the Mercury, Gemini, and Apollo space programs, which aimed to develop capabilities for manned spaceflight and exploration. These spacecraft re-entered the Earth's atmosphere at hypersonic speeds reaching around Mach 25. This era was characterized by rapid progress in rocketry and space exploration, driven by ambitious superpowers competing for national prestige and displays of ingenuity.

**Cold War – 1970-80s**

The 1970s and 80s are primarily highlighted by a further emphasis on hypersonic technology development, specifically in space exploration, and the primary social groups at the time were public environmentalists/advocats and strategic military planners. The United States Space Shuttle program, initiated by NASA in the early 1970s, aimed to develop a reusable spacecraft capable of carrying astronauts and cargo into low Earth orbit. In response, the Soviet Union developed the Buran Program, also aimed at developing a reusable space plane of similar purpose to compete with the United States. Both of these programs utilized hypersonic technology, and emphasize the change from focusing on simply developing hypersonics, to developing them in more innovative, creative, and affordable ways. These examples highlight the non-stop, back-and-forth competition between the two global superpowers at the time, and how hypersonic technology was used as a metric to determine superiority and success.


Figure 5: Space Shuttle (European Space Agency, 2007)

**Post-Cold War – 1990-2000s**

The post-Cold War era was a time of shifting global power dynamics and thus accompanied many military technological developments. Primary social groups included former Cold War rivals and private aerospace companies characterized by international collaboration, commercialization, and globalization. This led to the diversification of hypersonic research efforts due to the evolving security threats arising from geopolitical issues like the dissolving of the Soviet Union. The United States began shifting to the development of hypersonic glide vehicles driven by the need to adapt to emerging challenges such as asymmetric warfare and the proliferation of advanced missile technologies. China also started to become a player, investing in hypersonic cruise missiles. The post-Cold War era saw an increase in international collaboration and research initiatives focused on hypersonic technology. Countries and organizations worldwide partnered to share expertise, resources, and data to advance research and development. Private companies and research institutions also explored and made use of these technological advancements and explored the potential for hypersonic flight in commercial aviation, space tourism, and high-speed transportation in the future. This era witnessed a surge in

research, development, and experimentation, and ultimately paved the way for future innovations and applications relating to hypersonic technology.

**Modern Day – 2010s-Present**

In the 21st century, the socio-political impacts of hypersonic technology have been increasingly pronounced, driven by a combination of geopolitical competition, technological advancements, and evolving security threats. Russia and China have emerged as key players in the hypersonic arms race, leveraging their respective technological capabilities to develop and deploy hypersonic weapons systems. The reemerging competitiveness highlights the social groups defined during this period, including emerging players, innovative companies, and privatized research institutions. This modern-day competition reflects broader shifts in international relations, with hypersonic technology becoming a focal point for strategic competition. The dynamics surrounding hypersonic technology today are characterized by a mixture of cooperation and competition as countries seek to navigate the current geopolitical climate. The intense competition between the United States, Russia, and China continues to raise reg flags revolving around arms races and destabilization. This underscores the importance of understanding the broader geopolitical context in which technological advancements occur, especially regarding hypersonic technology. Furthermore, many experts are worried about whether hypersonic technology will fall into the wrong hands due to the increased attention and technological developments being made. The proliferation of hypersonic missiles for example, beyond the United States, Russia, and China, could enable other states to more credibly threaten attacks on major powers (Rand, 2017). This underscores the increased need for international powers to collaborate and safely manage this technology for the better, and to also maintain positive relations for mutual benefit.

## Limitations

While this analysis provides valuable insights into the socio-political impacts of hypersonic technology development, it is essential to acknowledge certain limitations inherent in the research. Firstly, the focus on broad socio-political trends makes it easy to overlook nuances and contextual factors specific to individual countries, regions, or technological programs. Variations in political systems, cultural norms, economic conditions, and technological capabilities significantly influence the trajectory of hypersonic technology development and are not fully captured in a chronological overview. Additionally, the historical analysis is limited by the availability and reliability of archival sources, particularly concerning classified military programs and proprietary research. This could lead to gaps in our understanding of certain events, decisions, and actors involved in hypersonic technology development. Furthermore, the analysis predominantly emphasizes high-level policy decisions and strategic considerations, potentially overlooking grassroots movements, public perceptions, and marginalized voices that also shape the socio-political landscape. Finally, given the rapidly evolving nature of hypersonic technology and its ongoing development, this research provides merely a snapshot of historical trends rather than a comprehensive assessment, particularly with regard to what is to come in the future. Despite these limitations, this analysis offers a valuable foundation for understanding the socio-political dynamics surrounding hypersonic technology and provides a framework for further research and inquiry into this complex and evolving field.

## Future Research

Moving forward, researchers should strive to address the identified limitations and expand upon the insights gained from this analysis of hypersonic technology development. Firstly, conducting more detailed case studies and comparative analyses focusing on specific

countries, regions, or technological programs provide a deeper understanding of the diverse socio-political dynamics at play. Through examination, research allows the uncovering of overlooked factors, identify patterns, and generate more nuanced conclusions. Additionally, efforts to access and analyze previously unavailable or classified archival sources could enrich our understanding of key events, decision-making processes, and stakeholder perspectives. Another promising area for future research involves comparative studies of existing agreements in the realm of arms control, like the Missile Technology Control Regime (MTCR) and bilateral arms control treaties, which provide insights into the potential for multilateral governance structures tailored to the unique challenges posed specifically by hypersonic weapons. Collaborative research initiatives involving interdisciplinary teams and diverse stakeholders could facilitate knowledge exchange, enhance methodological rigor, and foster innovative approaches to studying the socio-political impacts of hypersonic technology. Additionally, examining the environmental ramifications of hypersonic flight, such as atmospheric pollution and noise pollution, alongside ethical considerations surrounding the use of hypersonic weapons, offers valuable insights into the sustainability and moral dimensions of this technology. Finally, given the ongoing evolution of hypersonic technology and its implications for global security, researchers should remain vigilant in monitoring developments, identifying emerging trends, and informing policy debates to ensure informed decision-making and responsible governance of this transformative technology.

## Conclusion

In conclusion, the analysis of hypersonic technology development reveals a complex interplay between technological innovation and socio-political dynamics, from World War II into the Cold War era, all the way to modern-day competition between major powers. This research

underscores the profound impact of hypersonic technology and its capabilities on military strategy, international relations, and societal values, highlighting the enduring significance of technological advancements in shaping global security landscapes. The broader significance of this research lies in its contribution to our understanding of how technological innovation intersects with socio-political factors to influence governance frameworks, security paradigms, and ethical considerations. Ultimately, the takeaway message of this research is clear: the development of hypersonic technology has far-reaching implications that extend beyond the realm of defense and technology, shaping the contours of contemporary geopolitics and challenging traditional notions of deterrence, security, and arms control. Navigating the complexities of the hypersonic age, informed by historical insights and different perspectives, it becomes imperative to foster dialogue, cooperation, and responsible stewardship to harness the potential of hypersonic technology for the benefit of humanity.

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