Hypersonic Transport Vehicles for Commercial Applications

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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 purpose of this thesis is to discuss the societal implications of hypersonic commercial transport vehicles in order to prove that this emerging technology would be a net positive for society and that the aerospace industry should continue its technological development. To this end, I refer to Consequentialism as an ethical theory to guide my supporting evidence. Through doing so, I am able to justify my position by creating a cost benefit analysis of each option while also taking into consideration how the social context and goals of our society in its current climate align with the emergence of hypersonic vehicles.

Hypersonics is currently a very compelling area of research in the aerospace sector, with the potential to significantly advance the technological infrastructure of the commercial airline industry. The arrival of a hypersonic airplane could enable the airline industry to provide flights at unprecedented speeds and could transform the global transportation network. For example, a typical hypersonic aircraft is estimated to "travel from Tokyo to Los Angeles in only 110 min[utes]" (Smith & Sziroczak, 2016). However, hypersonics, especially in the United States, is unfortunately still in its infancy. There is simply not enough known about hypersonics to integrate it into a product that could fulfill the requirements necessary for a hypersonic commercial aircraft. As a result, the societal effects of this technology have not been thoroughly discussed; this paper aims to draw from numerous sources to provide a holistic overview of this technology so that its potential implications are made aware. While I believe that hypersonic commercial transport vehicles are worth pursuing, it is equally important to outline the potential negative impacts on society to ensure that the benefits truly outweigh the drawbacks.

Consequentialism

To analyze the value and societal implications of hypersonic commercial aircraft, I use the ethical theory of Consequentialism as a guide. Consequentialism is the philosophical viewpoint that "normative properties depend only on consequences" (Sinnott-Armstrong, 2022). The theory asserts that an act is considered "right" if the total good outcomes outweigh the total bad outcomes, resulting in a net positive effect. Since this paper focuses on a technology that has very little precedent, it is important to recognize that the analysis presented later will be based on a concept of Consequentialism called "Objective Consequentialism" (Railton, 1984). This subcategory of Consequentialism claims that morally right actions are dependent on the actor's intended consequences rather than actual consequences. Contrary to "Subjective Consequentialism," Objective Consequentialism focuses on objectively probable outcomes based on informed and rational reasons and does not depend on anything inside the mind of the subject (Railton, 1984). My assertion is not based on idealism, but rather on a rational prediction of events. Hypersonics for commercial applications would have a direct result on a significant portion of the global population. Therefore, I elect to use Consequentialism because it allows me to use overall utility as the primary criterion for my assertion, which is important for a subject that affects many people in a vast variety of areas.

Hypersonics Background

Hypersonic speed is defined as a speed that exceeds five times the speed of sound. Since Mach 1 is considered to be the speed of sound, hypersonics is also defined as anything greater than Mach 5. Hypersonic Transport Vehicles are any vehicles that are capable of traveling at these hypersonic speeds and can include anything from missiles to spacecraft and even aircraft. For the purpose of this paper, the focus will only be on hypersonic aircraft due to its potential in the commercial airline industry.

The idea of hypersonic aircraft was born through the proposal of the supersonic combustion ramjet (scramjet) engine in the 1950s. Although an airframe-integrated scramjet was developed in the 1970s, it came at a time of little interest in such advanced concepts (Peebles, 2008, p. 14). NASA's Apollo program was approaching its conclusion, unmanned planetary missions failed to gain approval for follow-up missions, and the X-15 program, a research initiative testing a rocket-powered hypersonic plane, ended in 1968. There was simply not enough motivation for scramjet engine research to continue. It was not until the 1990s that scramjet research resumed, and only until then did the US have a sufficient body of knowledge to undertake flight tests of scramjet engine designs (Peebles, 2008, p. 24). In 2004, the first scramjet flight occurred through the NASA X-43 program, which propelled the vehicle to Mach 7 and was a crucial step toward establishing the potential for air-breathing hypersonic propulsion (McClinton et al., 2005). However, this program was one of only a few major programs that found meaningful data of hypersonic flight using aircraft. Since hypersonics has mainly been utilized for military applications, there has been limited development in the commercial industry other than these few governmental programs.

Looking at today's state of hypersonic commercial flight, there is one lone private company working to build the first hypersonic aircraft for solely commercial applications: Hermeus. Hermeus is a startup company based in Atlanta, Georgia that recently signed contracts with NASA and the United States Air Force (USAF) to invest in the research and development of high-speed aircraft ("Hermeus," 2021). Currently, Hermeus plans to conduct their first small autonomous test flight in 2023, which will act as a stepping stone for their ultimate goal of a hypersonic passenger aircraft which they plan to accomplish in 2029. Evidently, there has been a large initiative from both government and private sectors to research high-speed aircraft in the

past couple of years. One may question whether the motivation is fueled by overall societal utility, or rather as an ulterior motive, such as possibly an economic or political investment. While any of these factors may be partially true, I continue to assert that the development of Hermeus financially backed by NASA and USAF is beneficial to society and therefore morally admirable. The following section details my supporting evidence for this claim.

Analysis

There are a variety of different stakeholders that play a role in the decisions regarding hypersonic commercial aircraft. American politicians have a responsibility to uphold the reputation of the United States as a global superpower. China and Russia, other superpower countries, have made advancements in hypersonic technology and it's crucial that we don't fall behind in this race. Environmentalists advocate for eco-friendly technologies that help Earth, rather than harm it. For example, there is much hesitation by these groups to advance forward with hypersonic commercial aircraft despite the convenience that it could bring to the airline industry due to its high emissions. The aerospace industry constantly strives to innovate and push the boundaries of flight. Advancements in hypersonic flight would forever revolutionize the way that we fly here on Earth, similar to the Apollo mission's role in changing the playing field in terms of space exploration. Finally, travelers around the world wish to travel faster than ever before. The accessibility of hypersonic planes would make our world significantly more interconnected. Evidently, the future of hypersonic commercial aircraft is tugged in various different directions. I will delve into each stakeholder as well as the power that each one yields in order to better understand the current landscape of hypersonics commercial flight.

Politicians

The American government, especially in the Department of Defense, continues to compete with other superpowers for technological supremacy to this day. In a status report presented by Dr. Mark J. Lewis of the Science and Technology Policy Institute, Russia is building on the legacy of the Cold War by pushing for rapid operational systems and creating international partnerships with Europe and India (2019). Unlike the Cold War, however, China has also emerged as a frontrunner in hypersonics technology - they invested into infrastructure such as wind tunnels and testing equipment, have made extensive foundational research with universities, and have a research portfolio with a wide spectrum of topics, an advantage compared to the United States who have primarily focused only on fluids (Lewis, 2019). It is apparent that Russia, China, and other partnering nations have made a serious investment into hypersonics. As a result, politicians have made efforts to catch up to these countries by investing millions of dollars into the hypersonics industry. Successful efforts in hypersonics and establishing the first hypersonic passenger aircraft would boost morale among American constituents and would strengthen the reputation of the American politicians.

Environmentalists

As one might expect, aircraft require a substantial amount of fuel to fly. Aviation is one of the most energy-intensive industries, with estimates that emissions have increased by a factor of 6.8 between 1960 and 2018 (Lee et al., 2020). Unfortunately, hypersonic commercial aircraft would be no different. To illustrate its effects, I believe it is appropriate to compare hypersonic commercial aircraft with private jets because Hermeus' Halcyon commercial aircraft would only be capable of housing 20 passengers in one trip (Itungu, 2022). While this passenger load may be slightly larger than typical private jets, it is much similar than the normal airline aircraft that can carry hundreds of passengers in one flight. According to Gössling and Humpe, private air travel

is responsible for 7,500 tons of carbon dioxide emissions per year and that 1% of the world population emits 50% of carbon dioxide from commercial aviation (2020). It is fair to predict that hypersonic commercial aviation will have similar if not worse emissions and will only worsen the effects that aviation has had on the environment.

While there is no precedent for hypersonics for commercial applications, there has been one example of a jetliner that taxied passengers at supersonic speeds, which range from Mach 1 to Mach 5. In the 1970s, the Concorde operated for about 3 years transporting passengers at a speed of Mach 2 (Candel 2012). However, due to economic and environmental concerns, noise pollution, and sonic boom problems, the historic plane shortly retired from operational use (Siuru & Busick, 1994). Current theory indicates that excessive nitrogen oxide emissions, especially caused by supersonic transport vehicles, could "severely damage the earth's atmosphere by contributing to the deletion of the earth's ozone layer" (Siuru & Busick, 1994, p. 154). Based on the environmental concern of supersonic transport vehicles, it is fair to assume that hypersonics will have similar and potentially worse impacts on climate change.

Aerospace Industry

Hypersonic aviation is currently an untapped market that could skyrocket the aerospace industry with a proof of concept. As mentioned before, there is only one company currently working on hypersonic aviation - Hermeus. A success story for Hermeus' Halcyon passenger aircraft would play an immense role in providing more jobs to further advance the technology. Competition would develop and a whole subfield of the aerospace field would emerge, striving to innovate on airframe design, propulsion, testing, and control in order to produce the best product for the hypersonic aviation market.

Specifically, hypersonic aviation is still facing issues involved with the structures and materials. Firstly, Peebles and Allen state that an emphasis needs to be made on the development of anisotropic materials, such as laminated, honeycomb, fibrous, and prestressed materials. Successful research into these materials may be applicable on a hypersonic aircraft to withstand both steady-state heating and brief, intense forms of heating (Peebles & Allen, 2011). Additionally, another issue involves non-steady, extreme temperatures. Research will "not only involve structures but aerodynamics, materials, cooling, and a large number of other fields" (Peebles & Allen, 2011). Hypersonic aviation would open up the industry to a vast majority of new fields that would require new jobs to accomplish these unprecedented requirements. If aerospace corporations are willing to invest the money into hypersonics research, the industry would surely boom with the success of Hermeus' proof-of-concept mission.

Travelers

While hypersonic commercial aircraft have the potential to significantly change the airline industry, I believe that it will not affect a large portion of travelers until many more years into the future. Right now, Hermeus is only working on an aircraft capable of holding up to 20 passengers (Itungu, 2022). This means that only the elite members of society will have access to this luxury, and the impact to the rest of the demographic will remain largely unchanged. Moreover, hypersonic flights are limited to transoceanic routes due to its sonic booms (Prisco, 2021). Therefore, the scope of travelers affected reduces further to those only wishing to travel across the Atlantic or Pacific Ocean. Travelers, on an individual basis, will not have a significant role in hypersonic aviation except for the truly elite class that can afford such luxury. However, large corporations, people with medical emergencies, or people in need of urgent family visits may benefit from the potentially crucial reduction in travel time. As mentioned above,

hypersonic flights could reduce flights by over half the time of a conventional commercial airliner. While the scope of the target market of hypersonic aviation might be small, the effect it may have on these travelers could be massive.

Discussion

Through my analysis of the stakeholders involved in hypersonic aviation, it is apparent that there are both advantages and disadvantages in its societal implications. I will begin with the disadvantages.

The environmental concerns are very alarming and are contrary to the initiatives currently being pushed by the aerospace industry's leading companies. For example, Rolls Royce, one of the world's leading aerospace engine producers, pledges to become a net zero carbon emissions company by 2050 ("Rolls Royce", n.d.). It would be unethical for companies to renege on their promise of sustainability in an attempt to profit into a new market. On the other hand, I would argue that hypersonic aviation, especially in the short term, would not have the volume to significantly affect climate change. Considering that there are thousands of flights every year with no simple way to address its environmental issues, the introduction of hypersonic aviation would be a negligible increase in emissions compared to today's standards. Of course, the overall goal is to eliminate emissions entirely, but it would not be detrimental to society if hypersonic flights occurred a couple times per year.

Secondly, the lack of accessibility of this new technology is another disadvantage, allowing the top income earners to have more privileges than the rest, which would not increase overall utility. As a counterargument to this disadvantage, I would say that hypersonics has the potential to become normalized with more research and development into areas that can improve the design of the hypersonic aircraft. Increase in competition due to the larger body of

knowledge of the technology would enable travelers to fly on these planes at more affordable rates. Only time will tell how successful hypersonic planes will end up and if it can become more widely accessible to the public.

A strong advantage of hypersonic aviation is that becoming the first country in the world to develop a hypersonic plane for commercial applications would be a boost for the United States as a whole. It is very important that the people of the United States maintain a sense of patriotism. With the government also highly investing in hypersonics research, a successful hypersonic airliner may motivate more Americans to join the military to further improve the state of the country. Being the first country to develop a hypersonics commercial aircraft would not only be beneficial to politicians, but will strengthen the system of our society as a whole.

The aerospace industry is without a doubt the stakeholder that would most support the research and development of hypersonic commercial aircraft. As asserted before, there is clearly an untapped potential in this field. Not only would companies see enormous profit, but aerospace engineers would be opened up to a new field with a large demand for innovation.

After outlining the cost-benefit analysis, I maintain that hypersonic aircraft would be a net positive for society and would benefit a variety of industries and stakeholders. While environmental concerns are still important, I argue that the development of hypersonics is a priority and that solutions to fuel emissions can come once the technology has become more established.

Conclusion

In summary, the introduction of hypersonic commercial aircraft into our society is morally right in the lens of Consequentialism. After analyzing the current landscape of hypersonics in the United States, I outlined the numerous stakeholders involved in this topic and

the power that each one yields in the decision making processes regarding hypersonic commercial aircraft. This field is still incredibly new and it is difficult to find a precedent that could be used to predict the outcome of events in the future. However, with companies like Hermeus pioneering this innovative project, time will only tell how hypersonics will play a role in our society.

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