An Anecdotal Analysis of Modern Hypersonics Programs

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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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Hypersonics: In Perspective

Hypersonics, by today's generally accepted definition, is the study of systems in a speed regime greater than Mach 5, or five times the speed of sound. Due to the potential strategic advantage of flight vehicle operating at such speeds, hypersonics and hypersonic weapons have become an area of intense academic and military research.

In some ways, the race in hypersonic weaponry today is reminiscent of the nuclear arms race of the mid-20th century. It was a time when the best and brightest minds in almost all engineering specialties made the furtherment of that technology their crowning achievement in their academic careers. However, as history shows us, many details about the eventual utilization and implementation of those same weapons developed by their work were unknown to them. I believe that there should be greater transparency around the intentions of defense projects, so that those who join understand fully what it means for them.

For aerospace academia in particular, the department of defense (DoD) and the defense industry have always worked in very close coordination with universities across the United States. For my STS research paper, I want to explore the ethics of the methods in which aerospace academia feeds into defense research projects. I want to explore how research projects are advertised to university students and faculty, and the relationship between the university and the defense complex. I will be performing a historical analysis on nation-wide defense efforts, and an analysis on modern hypersonics programs at the academic level. I will also utilize anecdotal evidence from students and faculty from the aerospace engineering department here at the University of Virginia (UVA).

Hypersonics: Historical Precedents

Hypersonics, despite the glamor surrounding the field of study in recent years, is in fact a very old idea. Since the inception of heavier-than-air, powered flight, the idea of flying at faster and faster velocities was always very present in the field of aerospace academia. Thus, the idea of hypersonics and hypersonics weapons has been around for longer than is expected. The strategic advantage of hypersonic and ICBM technology is clear: to strike in a short enough window of time that existing defense systems will be unable to intercept the strike. To quote *An Offensive Leap*, "A country may be capable of identifying the launch of a hypersonic weapon, but it will be unable to ascertain its target" (Yohoe 1). Understanding the strategic value that certain defense projects bring to the overall issue of national defense is important when analyzing why certain projects are pushed to begin with.

For the first case study, I wanted to look into the first hypersonic weapon, which was created during later stages of WWII by the Nazi party. They were credited with the development of the first hypersonic weapon as well as the first long range ballistic missile, the V2 rocket. The V2 rocket consistently reached speeds of up to Mach 5+ upon reentry, and was most infamous for the targeting and bombing of London.

Spearheading the team responsible for the design and engineering of the V2 rocket was Werhner von Braun. Werhner von Braun was most widely known for his work in the Apollo space missions in the United States, but hailing from Germany, he was also the lead engineer for the V2 program, and other Nazi military weapons development during WWII (Harbaugh 2016). It's been documented that Werhner von Braun worked under the Nazi army while getting his doctorate; his research was also being funded by the Nazi army (Harbaugh 2016). Following his education, he

was shipped off to the Peenemtinde Rocket Center on the Baltic, where he was technical director (Neufeld 2002). This was where his development of the V2 rocket began.

There are a few unknowns about Werhner von Braun's relationship with the Nazi party. It's unclear if his relocation to the Baltic was consensually agreed upon. It is known that he was an officially affiliated member of the Nazi party, but it is unknown whether or not Werhner von Braun was actually morally against the party's ideologies or not. To quote Michael Neufeld in his analysis of Wehner von Braun's life, "there is no evidence for anti-Semitic statements or acts on his part" and, in addition to that, "his 1947 affidavit asserts that he had been "officially demanded" to join the Party in 1939" (Neufeld 2002).

When Werhner von Braun was heading the V2 rocket project at the Peenemtinde Rocket Center, he was arrested in 1944 for treasonous behavior, due to his growing dissatisfaction and disillusionment with the Nazi regime (Neufeld 2002). He was later released. Sources suggest that Werhner von Braun's disillusionment was most likely related to the use of concentration camp labor for the mass manufacturing of the V2 rocket due to a shortage in skilled German workers. This phenomenon was not limited to the V2 rocket production plant; other factories also used slave labor from concentration camps (Harbaugh 2016).

The discussion about the moral controversy surrounding Werhner von Braun is an ongoing debate. However, from the evidence and timeline of events, the coercive methods used by the Nazi party to control scientists and engineers like Werhner von Braun becomes clearer. Werhner von Braun was likely scouted from a young age by the Nazi party as an invaluable resource to their developing projects. The Nazi party leveraged their earlier funding in Werhner von Braun's research and education, and very soon after coerced him into joining the Nazi party. It is unlikely that Werhner von Braun held many patriotic sympathies towards the Nazi party, and joined due to

"official demands", but also in order to keep himself and his research alive. There was most likely an element of self-preservation as well towards any threats to his personal safety. The Nazi party, by securing these actions, then have total legal and social control over Werhner von Braun, and can focus his efforts on weapons projects that benefit the regime, regardless of his own moral objections or opinions regarding these projects.

It can be counter argued, however, that methods such as contractual agreements like educational scholarship for military service or working on military projects, and projects supporting national defense are perfectly reasonable, and is in fact very common the United States.

While this is true, there have been previous projects where crucial details were unknown to even those most senior on the team, and much of that can be attributed to how the project was advertised to those who work on it. The second case study in question is that of the Manhattan Project: the secret development of an atomic bomb for the United States.

During the Manhattan Project, the United States government deceived the scientists working on the project by withholding critical information and misrepresenting the true nature of the project. The instantiation of the Manhattan Project originally was only in response to news from Albert Einstein to President Truman that the Nazis had discovered nuclear fission, and were in process of developing an "extremely powerful bomb" (Gosling n.d.). Much was shrouded in secrecy, and scientists as well as many others working on the project were often kept in the dark about the overall goals of the project and the true potential of the atomic bomb. Many scientists believed that they were working on a project to develop a new type of explosive, but were not aware that the end goal was the creation of a weapon of mass destruction. In an interview with Robert Oppenheimer, he noted how that none of the scientists really understood the scale of potential devastation of the bomb, and that the "problems understanding the process of the

explosion in order to get some rough idea of how big to make the bomb were very difficult theoretical problems and not really solved because we did not know how big the explosion would be." (Oppenheimer 1965). Based on Oppenheimer's words, it demonstrates that even the most senior of scientists overseeing the project were unaware of its lethal potential.

In addition, scientists and engineers were often misled about the risks and dangers associated with their work, and were not informed about the potential health effects of exposure to radiation. It's been shown in autopsy that the Plutonium exposure experienced by workers in the Los Alamos National Laboratory significantly increased the likelihood of bone cancer (Boice 2021). This deception had significant ethical implications, as it deprived those involved of the ability to make informed decisions about their involvement in the project, and prevented them from fully grappling with the moral and ethical implications of their work. Yet still, Robert Oppenheimer points out how he went from "university to university" in order to recruit young graduates for his program (Oppenheimer 1965).

Robert Oppenheimer, as a scientist and a human being, faced the ethical questions about whether it was right to create a weapon capable of potentially killing thousands of people, many also potentially civilians, in an instant. As a part of President Truman's Interim Committee discussing how best to use the atomic bomb, he and some of his colleagues appealed that the bomb should only be used as a warning demonstration, but ultimately, the decision to drop the bombs on Hiroshima and Nagasaki was made by President Truman and the rest of his Interim Committee (Gosling, n.d.).

After the war, Robert Oppenheimer became an advocate for nuclear arms control and disarmament. He argued that the development of the hydrogen bomb and the subsequent arms race posed a grave threat to humanity. He also advocated for greater democratic oversight and

transparency in scientific research. His views on these issues were shaped by his experiences during the Manhattan Project and his later reflections on the morality and ethics of nuclear weapons.

In this case study, I don't believe that the United States government was being purposefully coercive as the Nazi party had been with Werhner von Braun. However, there was still a form of deception surrounding wartime projects like the Manhattan Project. Crucial information regarding the intent was withheld from the scientists and engineers working on the project. To those people, it was described as "a race to acquire the bomb" (Gosling, n.d.). The consequences of the utilization of such technology were not fully explained to those who should have known prior to joining the project.

In both cases, the V2 and the Manhattan project were highly secretive, highly prioritized national defense/offense projects. Being such, there are elements of ethical consideration for those who undertake the responsibilities of working on such projects, but there is also an ethical consideration of the governing bodies who oversee the development, advertising, recruiting of the project, and most importantly the transparency in which they go about these decisions, and their dedication to worker safety. As can be seen from these two case studies, the methods can vary drastically, and can sometimes have serious implications for the workers involved. I'm concerned that similar ethical oversights may be occurring today in the field of hypersonics research.

Hypersonics: Here At UVA

For my STS research project, I interviewed 14 students here at UVA who were involved in hypersonics, either as a part of their 4th year capstone project, or for research at Aerospace

Research Lab (ARL). Just to clarify, the 4th year capstone project this year is a hypersonic reentry deployable glider experiment (HEDGE) and involves hypersonic data research. There are also many hypersonic related projects ongoing at ARL. As a part of my interview, I asked each undergraduate or graduate student three primary questions:

1. What proportion, roughly, of the projects which you work on have DoD funding?
2. How aware are you of the funding sources behind your projects?
3. Are you okay with your work potentially being used for the military?

My reasoning behind asking my interviewees these questions was that I wanted to test their overall awareness of the impact of their work. In the case studies introduced earlier, one of the biggest issues faced by Werhner von Braun and Robbert Oppenheimer were that they were so heavily monetarily invested in by the Nazi Party and the U.S. Government to head such important defense projects, that any ethical rationalizations they had of what they were doing became secondary in importance. This is most likely true of the men and women who worked under them as well, because for most, working in defense and defense projects is first and foremost a job. I would argue that the responsibility these people held to those dependent upon them outweighed any moral contradictions. Furthermore, with large scale projects like the Manhattan project, the V2 project, and nowadays with modern hypersonic weapons projects, the further down the level of technical abstraction one goes, the more disconnected one is with the actual intentions of the project itself. A truck driver, a clerk, a line cook, for example, may seem unrelated to the furthering of hypersonic technologies, but each plays their part. I also worded my questions specifically to place those answering the question in the mindset of an actor in the actor-network theory frameset (ANT), with each of them representing a node that is part of a greater hypersonics and aerospace network at the university level, which is also a part of an even greater defense networks like support,

logistics, system integration, government, etc. It's easy to lose track of where you stand in the greater picture of defense, because there really are so many layers. I wanted my interviewees to think about where they fit in relation to the defense industry, and also of where they would like to be.

Expectations and Results

I was expecting a variety of answers. However, I had some expectations as to what kind of answers I would not receive. I was not expecting any responses that showed complete ignorance to the relationship between the aerospace industry and the defense complex. On the other hand, I was also not expecting responses which cited that working for the defense complex was the only reason he/she had chosen to pursue aerospace engineering. One thing I wanted to clarify is that, for questions 1 and 2, I had worded the questions as to ask about "projects" mostly referring to research projects, but when conducting the interview, I added that previous employment was also an accepted answer

Some trends from my results:

- 10/14 of the students responded that at least some of their funding came from the DoD and or they had done work previously for the DoD
- 11/14 students responded that they did know their funding sources, to a certain extent. When pressed further, only 5/11 students could name at least two of their sources.
- 8/14 students responded that they were okay with their work having a direct military application, although that was not necessarily a pro or a con for them.
- 2/14 students responded that their work having a military application was a pro for them

- 4/14 students responded that their work having a direct military application was a con for them.

I noticed two very interesting trends. The first came from the results of the first two questions. Out of the students who knew somewhat where their funding came from, almost all were tied to the DoD in some fashion. This didn't necessarily surprise me, since hypersonics has such a heavy emphasis within the defense community. Those who are not working on hypersonics from a defense standpoint, are looking at purely academic phenomena that occur at those extremely high temperatures and pressures that are exerted onto a hypersonic platform, and unfortunately such opportunities are not as bountiful as defense-oriented opportunities. The second was arguably more interesting, which came from the results of the third question. Most students did not have a preference whether or not their work had a direct military application. To me, this was very surprising. I had expected the answers to be much more polarized than they were, and for a majority of students to take a stance on either side of the fence, but what I received was general apathy. Some students were quite firm in their response about not having a preference, which lead me to believe that they had thought about this question before, and quite thoroughly at that. However, it was clear that for some students, this was their first time ever considering this question.

There is one response that I believe brings up some interesting points, as well as incapsulates the average response well. In order to maintain anonymity, I will be removing possible identifiers.

"Technically, the funding for my degree program comes solely from a project funded by 'undisclosed'. That being said, I am also involved with two other projects that are funded

by DoD and handle controlled unclassified information. For projects like these, we actually need to be very aware of our funding sources, as it impacts the entire process with which we handle data that we collect from experiments. Personally, I am fine with my work having direct military applications, as I don't see anything wrong with the defense of a nation, especially when it is an effort to catch up with the technology of other nations. I do know that there are others that I work with that would prefer to be a little less connected to military applications, and there are funding sources and projects with goals that are less morally ambiguous, I guess. We can use our facilities to study things like diesel engine efficiency, reentry plasma characteristics, and material deposition rates, for example. Working on defense related projects isn't something that I think should be glorified or anything, rather it's work that needs to be done regardless of who does or doesn't want to get their hands dirty."

This sentiment about how working on defense projects is not something to be glorified, yet is at the same time arguably necessary work was also echoed by several other students. I believe that too often defense projects in the United States are seen from the lens of a morally superior position, and that because it is for the defense of a nation that such defense projects somehow become exempt from other ethical considerations. When discussing defense related issues, the idea of "freedom" is often brought up. This idea is central to the American history as well as American identity, and again, there is this idea of moral superiority that comes into play. While "freedom" itself is not the issue, it is often projected into the forefront of the ethical reasoning of defense projects despite what other details of the project may indicate.

Undergraduate and graduate engineering students are the major pipeline feeding into private defense contractors who are tasked with the design, test, and fielding of hypersonic weapons and other conventional weapons. In the study performed by Hersh (2021), which looked to examine the ethics of engineers and scientists involved in military work, it was found that while some participants of the study had a "traditional approach" towards defense, most participants were quite self-aware of the impact of their work, and it was important to them that their work be consistent with their idea of social progress. It is true that most university students are legal adults, and that they have the means and ability to choose what profession to pursue and to embrace everything that is associated with it. However, for a student who wishes to pursue a field like aerospace engineering, avoiding military backed projects can be difficult. It can be argued that the difficulty in pursuing this field without sacrificing one's morals, if one should feel strongly against the militarization of their work, is a real problem. It can also be argued there should be a productive way for those who have no intention of having their work associated with the development of hypersonic and conventional weapons to contribute to aerospace engineering research.

However, regardless of defense or non-defense related projects, I strongly believe that there should be increased transparency surrounding the intentions of these initiatives. It's essential that individuals who join these projects have a clear understanding of the objectives, as well as the potential outcomes of their involvement. This will benefit both the workers and the make such projects more efficient. By being fully informed, individuals can make educated decisions about their participation, based on their personal beliefs and values. This ensures that workers will be more motivated to do work that they truly believe in and find purpose in. This transparency can also help to promote accountability within the defense industry, ensuring that projects are conducted with a high level of integrity and ethical standards. Overall, increasing transparency

around defense project intentions is essential for promoting informed decision-making, ethical practices, and accountability within the defense industry.

The Bigger Issue

Hypersonic weapons have been in development for a long time, yet they still represent a developing weapon system. The hypersonic flight regime is an incredibly challenging environment, and significant research is still ongoing into the development of these systems. Through my STS project, I aimed to acquire a deeper understanding of how the aerospace and military sectors work together, and to gain insight into the level of involvement that academia currently has in the fielding of new hypersonic technologies.

While it may be several years before the United States is able to field its own hypersonic vehicles and usable hypersonic weapons, it's more critical now than ever that new generations of engineers are aware of the implications that their actions have on the safety and security of the nation and the rest of the world. The development of hypersonic technologies could lead to a significant shift in the global balance of power, and it's vital that engineers involved in this field consider the broader impacts of their work.

Furthermore, it's essential that we promote ethical considerations and accountability within the development and deployment of new technologies. As we push the boundaries of what is possible, it's critical that we do so in a responsible and safe manner. This requires not only technical expertise but also a thorough understanding of the broader societal and geopolitical implications of hypersonic technologies. Ultimately, by promoting transparency, accountability, and ethical

considerations, we can help ensure that the development of hypersonic technologies benefits humanity as a whole, rather than contributing to further instability and insecurity.

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