The Ethics of Engineers' Role in Militaristic Technologies

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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

As a fourth-year student at the University of Virginia in aerospace engineering, a capstone project was given to design a light attack aircraft. Many different components must be taken into account when designing any type of aircraft, including but not limited to weight, propulsion, fuel efficiency, aerodynamics, size, and cost. However, when specifically designing an attack aircraft, defensive mechanisms must be included as well as armament and weaponry. A question of ethics arises when designing something that causes harm: does the engineer's role in improving military technology benefit society regardless of the required means? Throughout this semester, a course on engineering ethics is being taken alongside the progression of the capstone project, which will help stimulate the conflict of this ethical dilemma that is faced by many scientists and engineers everyday, and is now being faced personally while designing a light attack aircraft.

The purpose of a light attack aircraft is to support ground troops by conducting attacks from the air in the form of strafing while maintaining certain size, weight, and cost restrictions (Light Attack, 2020). Throughout history, engineers have aided the military with designing and building attack aircrafts and other military technologies. As an engineer, it is important to recognize the ethical controversies surrounding whether it is in their best interest to build and design something that will harm others. It is thought that engineers should use their abilities to make life easier and to improve systems for the betterment of others. Engineers' and scientists' roles in military operations could be seen as heroic and good for society if one looks at the defensive and protective aspect. If improvements are being made to protect the United States and the people living in it, this is ultimately good for society. However, it can also be seen as harmful to society when focusing on the offensive side of war. Ultimately, lives are being stripped away at the expense of these technological advancements. This isn't simply a question of whether or not the engineers are being ethical or not, it is also a question of how ethics are perceived differently by each party involved. Moving forward, it will be important to ask questions regarding how engineers view ethics and if they believe they should incorporate it into their work. This can also lead to several other questions about whether scientists and engineers should simply focus on the defensive side of military operations, that way their actions are protecting society without harming others. However, would society benefit more from attacking others who intend to cause harm in order to prevent further damage? All of these considerations should be taken into account when creating something that could be detrimental to others, specifically in this case, when designing a light attack aircraft that could kill people. Further investigation into this complex problem can provide insight to all sides of the argument and help understand how this large system impacts the way engineers view their ethics, as well as their role in society and in designing a light attack aircraft.

Literature Review

Before moving forward, it is important to provide evidence and highlight previous research studies and perspectives on the ethical dilemma of engineers creating weapons. When facing this complex problem, there is no simple solution, or a right or wrong answer. Many other problems must be addressed within this topic, with the hope that a better understanding and a general consensus may be the result. Several books, articles, and reports have introduced this problem in different ways, and many have provided a wide variety of possible solutions. Previous research into this topic has also included studies and surveys to help gauge the complex layers of ethics and how it applies to engineering in war. Although, most of the research had a recurring theme of how engineering ethics applies to nuclear war, and mostly strayed away from simpler, more practical military technologies. Also, previous literature does not have an emphasis on attack aircraft specifically, which is what this capstone and thesis will focus on.

Upon addressing this dilemma, the first problem to consider is how people view ethics. Ethics can be perceived differently depending on the situation. At work, ethics may be a set of rules that must be followed given a company policy. Individually, it can be a moral code. For engineers, it can differ based on personal views and company policies, but they also have a standard guideline they have to follow that is laid out in the National Society of Professional Engineers (NSPE) Code of Ethics. According to the Code of Ethics, the services provided by engineers require honesty, impartiality, fairness, and equity, and must be dedicated to the protection of the public health, safety, and welfare. Engineers must perform under a standard of professional behavior that requires adherence to the highest principles of ethical conduct (National Society of Professional Engineers, 2019). Aside from these technical guidelines, researchers still believe that it can be taken further. Michael Davis, author of Ethical Issues in the Global Arms Industry, says that other than what is outlined according to the NSPE, ethics can be divided into three categories: morality, ethics, and moral theory. The latter refers to more of an attempt to understand morality as part of a reasonable undertaking (Davis, 2015). Engineers' actions and responses to their ethical dilemmas is entirely dependent on how they perceive that dilemma. Although Davis clearly indicates the importance of ethics in professions, especially in engineering, others fear that it causes a strain on people's work and is too heavily focused on. Some researchers believe that guidelines, like those laid out in the NSPE code of Ethics, should not be part of the profession. In an article titled There's No Such Thing as Engineering Ethics, author Coy Veach believes that we "have made the concept of ethical behavior so complex and confusing that we fail to act" (Veach, 2006). Furthermore, Veach says that specifically for engineering professions, ethics should not be necessary if it blinds them to their work at hand. Ultimately, the concept of ethics is extremely broad and different for everyone, and it is important to consider in professions such as engineering, but we must avoid overcomplicating it to the point of mass confusion, or else technological improvements may come to a complete halt.

Once the problem is better understood, one can start to understand engineers' roles in creating something that harms others. In his book, Controlling Technology: Ethics and the

Responsible Engineer, Stephen Unger argues that it is the engineer's responsibility to develop and apply technology that is directed toward humane ends. The outcome of the use of the technology is entirely the fault of the engineer who created it (Unger, 1994). On the contrary, other researchers argue that engineers are not solely to blame for how society uses their tools and technology that they make. Engineers, along with their fellow citizens, are equally responsible. Some believe that "engineers must humbly recognize the many dark pages of history for which they--along with their fellow citizens--share responsibility." (Florman, 1989). Florman continues in his research and publications to relate this shared responsibility to advancements in military technology. He believes that even though engineers contribute to war by improving military weapons that cause harm, engineers do not control the result of those weapons. "Engineers do not make people war-like. People are not more aggressive with guns than they are with clubs." (Florman, 1989). His argument concludes that regardless of the advanced weaponry and technology, the users have just as much power and responsibility over the result as the builders. Similarly, in his book, War and the Engineers: The Primacy of Politics Over Technology, author Keir Alexander Lieber says that although some technological advancements may cater to war while others cater to peace, the technology itself does not promote one over the other. Furthermore, Lieber believes that politics is the major contributor to harmful actions such as offensive aggression in war by acting as the decision-maker and the leader of the builders and user of the technology. Overall, "technology alone cannot influence war, but it is politics that play a much larger role… politics is the master, technology the servant." (Lieber, 2008).

A real-life scenario of an engineering militaristic ethical dilemma was the Manhattan Project; the creation of the atomic bombs that killed thousands of civilians in Japan to end World War II. Many researchers use this as an example of how important ethics are for engineers, especially those working with military technology advancements. Penny Gilmer, author of a research paper on the ethics of the Manhattan Project, says that one of the best ways to address this problem is to teach and understand it at a young age. She says that it is critical to teach students the social and ethical responsibilities of scientists and engineers so that in the future, they are more aware of the implications of their work (Gilmer, 2002). Within the Manhattan Project, many scientists and engineers came forward years later saying they regretted their participation in the creation of the atomic bombs. According to Gilmer's beliefs, these scientists would have been better prepared for their ethical dilemma if they had been taught those responsibilities previously. Unfortunately, those scientists failed to understand the implications of their work, including most notably Robert Oppenheimer. Oppenheimer was a lead scientist for the Manhattan Project and came forward years later stating his disappointment and regret. He said the infamous line that he has "become death, the destroyer of worlds." In a research panel conducted by UC Berkeley, Professor Joonhong Ahn said that he believed Oppenheimer's motivation was patriotism: he was simply doing what he could for the United States (Ahn, 2014). Instead of using a guideline of ethics, a moral conscience, or a previously understood implication of his work, Oppenheimer viewed his patriotism as an effective ethical means, only to regret it years later.

Currently, there are systems in place that attempt to address this ethical dilemma like company codes of conduct, the previously mentioned NSPE Code of Ethics, and even federal laws. For example, the Arms Export Control Act, the International Traffic in Arms Regulations (ITAR), and the Arms Trade Treaty (Fichtelberg, 2006). All these regulations help control how the military technologies are implemented and shared, which should make engineers and scientists feel better about their involvement with weaponry. This brings up a relevant question posed by Aaron Fichtelberg in his report on Applying the Rules of Just War Theory to Engineers in the Arms Industry: since there are so many policies in place to protect others and to ensure that workers are holding up to moral standards, why do engineers still face this ethical dilemma? (Fichtelberg, 2006). In Samuel Florman's book, The Civilized Engineer, he outlined a study that was conducted by the Institute of Electrical and Electronics Engineers. They gave a questionnaire to thousands of engineers, and 39% of respondents said they would prefer not to engage in work with defense technology (Florman, 1989). This proves that regardless of previous attempts at a solution, this problem requires further attention and more perspectives. A company, organization, and even the federal government are all incapable of predicting and understanding the ethics of all individuals. Unfortunately, all systems in place to address engineering ethics are a one-size-fits-all kind of deal. Like Gayle Davis said in her paper titled A Study in Engineering and Military Ethics, "there is not one solution to this problem, one attempt may be useful and important, but none by itself is likely to be adequate." (Davis, 2008). Davis and many other researchers that were discussed all come to the same conclusion: the ethical dilemma that engineers face when creating different technologies that can cause harm is a complex problem that does not have one right answer.

Throughout the research conducted, every researcher had their own opinion on what ethics is and how it should be applied to the engineering profession, which just further complicates the dilemma. This goes to show how complex this problem is, which is why it will be further reviewed and a study will be conducted in the future to gauge engineer's views on ethics in their workplace. Furthermore, this thesis will focus on the impacts of engineers creating attack aircrafts for military use since other researchers have failed to address this specific concept. With 19% of all aerospace engineers working in a military-related industry, attack aircrafts are constantly being built and improved on. Each of those aerospace engineers faces this problem as they work, including myself. Since I am designing an attack aircraft this year for my capstone project, I am personally involved and am facing this ethical dilemma head-on. Hopefully this research, along with more insight through other methods, will help others and myself fully understand the implications of our profession.

STS Framework

Attack aircrafts have been in combat for over a century now, but they did not necessitate vast improvements and manufacturing until World War II. Thus, the problem was born: countries across the globe needed to improve their military technologies in order to compete in the war. This dilemma is an example of a large technical system (LTS). New and improved designs of attack aircrafts began to transpire, with the integration and approval of society. People from their respective countries wanted to win the war and come out on top as the global superpower. Advancements on technology in weapons and defense was an effective means to achieve this. Therefore, society's interest was grabbed with the direction of this problem. Engineers began to be faced with this problem of creating new and improved weapons, all for the betterment of their nation and to win the war. Furthermore, the government gets involved in the system too. The Department of Defense is a department of the federal government who coordinates and supervises all things in relation to the armed forces, which impacts how weaponry is used and created. Therefore, the engineers, society, and the government all share a common goal and work together to achieve it.

Without the initial problem and shared common goal of the actors and actants in the system, then the technology involved would not be where it is today. Attack aircrafts would not be as necessary and would not be prioritized without the involvement of all participants, and the ethical dilemma would not have to be discussed. Without the engineers, these aircrafts would not exist due to their complex components and scientific research needed to create something so technologically advanced. Also, without the government's support and involvement, attack aircrafts would not be developed for the military since the military is a direct branch of the government. Furthermore, the government is held accountable by the people, so if society is no longer in support of the goal, the government must cater to the democracy. Lastly, without the active military members who use the attack aircraft, no harm would be caused at the expense of the network. Overall, all members of the network contribute to the outcome of the system. This means, within the large technical system, all participants share responsibility. The engineer alone is not to blame for the results of weapons they worked on.

Other participants include the government, the many scientists and engineers, members of the armed forces, and society. Since all of these participants are dependent on each other and are required in order to create the desired technology, all system builders share responsibility. This researched ethical problem also uses Actor-Network Theory (ANT). Along with the human participants, there are also non-human participants that share responsibility. All participants in this network are connected: human and non-human, and those who act on the system and the object that undergoes the action. When creating a light attack aircraft for military purposes, the engineer designing and building it is a human actor whose goal is to meet the requirements of the design and to create a finished product. The actant is the aircraft itself that performs the action of flying, protecting the pilot, and attacking the enemy. One of the actions performed by the aircraft is using the weaponry incorporated into the design to harm others. Those weapons are also

non-human actants recruited into the network that were put in place by the engineers and are used by those who operate the aircraft. The military personnel can be viewed as both human actor and human actant by using the aircraft and weaponry, and by acting as a direct result of the engineering actors. Over all, the final outcome of protecting or harming others is not because of the engineer who created the attack aircraft, nor because of the plane and weapons performing the act; it is the interplay between all participating members including the government, media, military pilots, engineers, and the objects used. There exists a translation among all active participants: actors and actants. It is the translation itself that produces the action. Without it, the system would not perform.

Designing and building weapons and mechanisms for militaristic use is also an example of ethics in action: the underlying goal is to do good for society by protecting the nation. However, by trying to do good for some people, is the process actually harming others unnecessarily? Defending one society may have to come at the expense of another. When getting involved in the military, either as an active duty personnel or as an engineer, you are told that your actions are helping, maybe even saving, civilians of your country. It is seen as honorable, admirable, and sometimes heroic to work for the nation's defenses. For engineers, the ethics behind their innovation and their action can be examined. There may be certain factors that come into play within a design that can make the weapon be seen as more or less ethical. For example, when designing an attack aircraft, more emphasis can be put on its defenses: the engineer can put the majority of the resources and funds into making the aircraft safe such as including ejection seats, armor, and resistant materials, as opposed to focusing on missiles and other attack systems. However, this aircraft would struggle to take out incoming enemies and would not be able to support ground troops as well. By trying to be good and more ethical by preventing mass harm to others, this kind of design may still cause harm by failing to aid those who might need it. Furthermore, by focusing more time and money on the attack systems of the aircraft, the resulting advanced weaponry would make it easier to harm others. Although that kind of technology is advanced and advantageous to the nation's militaristic power, it might not be ethically appropriate. Ultimately, by trying to do good, it appears that engineers designing weapons may provide both help and harm to others.

In the early and mid 1900s, a rise began in military, industry, and academic cooperation. This was first noted in 1940, when the National Defense Research Committee was contracted that tied together industries and universities for military research. Ever since, the prevalence of the military-industrial-academic complex has grown. For example, the design of a nuclear weapon system for World War II, known as the Manhattan Project, required the country's top scientists and engineers to work together. This project was heavily funded by the Department of Defense and also relied on and used university research for laboratories and nuclear physics departments. The scientists and engineers believed they were doing what's right for our country and felt patriotic and nationalistic for their involvement. The university students would be especially vulnerable to do whatever necessary to help their country. Later, many of the participants within the Manhattan Project admitted regret over their involvement; they were

simply overwhelmed at the time with the thought of doing something good. Even after World War II, military funding continued to increase, requiring more university science research. Although not all university engineering students are involved with weapons and defense research, it is still a prevalent topic. For example, the technical project that was given alongside this thesis to design an attack aircraft showed students the reality of this kind of work for the first time. We, as students, are making design choices among this project that could potentially impact military and civilian lives. Although, the students, as well as the industry workers, are not in direct contact with the outcome of their projected weapon design.

Engineers are simply doing their job and following orders, it is not necessary to focus on the long term effects, especially if they believe they are doing something honorable by improving the nation's defenses. However, could this be seen as a banality of evil? Could this thoughtlessness and absence of thinking be harmful even though those behind it have no evil motive or conviction? According to Hannah Arendt's Report on the Banality of Evil, evil is not always committed by those who have bad intentions. Evil is committed by those who don't think but are involved in a large technical system that itself produces evil actions. The LTS can make people forget and force them to not think about the outcome. A solution to this could be to provoke awareness to the individuals within the LTS, but this awareness will not automatically translate to a halt in militaristic technologies or to a proper ethical clarification. There doesn't seem to be a straightforward answer to this complex ethical dilemma. Regardless of the intention, harm and wrongdoing can still transpire; it is up to the engineer to decide if the ends justify the means.

Research Method

Many good points were brought up from previous research that outlined this complex problem well and provided insight into addressing it. However, current data still needed to be obtained that adhered more to the specifics of engineers designing a light attack aircraft. Upon data collection for this problem, it was expected that previous arguments made from the literature review and document analysis would be strengthened, and that new perspectives would be introduced more specific to the technical project. Some data collection methods that would accomplish this include interviews and surveys since more specific questions can be asked and directed through those means.

Data Analysis

Two different interviews were conducted: one with Adonay Jimenez, who is the owner and engineer of Alis Aquilae Engineering LLC, and one with Jesse Quinlan, who is the professor/mentor of the light attack aircraft technical design project and also an engineer at the

National Aeronautics and Space Administration (NASA) in Virginia. When asked about their thoughts on designing and building weapons, Adonay Jimenez said that people should know what they are getting themselves into when diving into a job. Many people simply will not accept a job that would involve weapons or the military. Therefore, when you accept a job, you also accept the inherent risks and ethical dilemmas that come with it. "You need to consider what you are choosing to do. Can you accept your work causing lives to be lost? While accepting that you are also protecting your nation's and your people's cause? If you are not comfortable, come to terms with that early on before you have to be faced with it." (Jimenez, 2021). Furthermore, Jimenez went on to mention that ethical dilemmas in the engineering workplace are ultimately systematic; the responsibility would never fall on one thing or person. Engineering work, especially attack and defense systems, are part of a large technical system with many builders and users. It cannot be analyzed separately; one ethical problem or flaw must go through the entire system.

Additionally, Jesse Quinlan was able to speak about his personal experiences with ethical dilemmas in aerospace engineering. Although he never worked directly with military weapons, his PhD research on scramjet and ramjet CFD analysis produced data that could aid with missile simulation. This kind of work made him uncomfortable and he realized it wasn't something he wanted to move forward with in his career. This also emphasizes the idea of a large technical system; even though Quinlan was not directly designing or building weapons, he still played an underlying factor in the improvement and development of them. This shows how it is never one person's responsibility, each person and part of the system plays an equal role. His experience caused some caution and weary when introducing the technical capstone project to us students: designing a light attack aircraft. Quinlan said that it is difficult yet necessary to reconcile the potential impacts from these types of projects. "Acknowledge that the dilemma exists… and focus on the work and on the good. Harming others is not your job, your job is to solve problems."

Along with the two interviews, a survey was created to gauge the thoughts and opinions of engineering students who may experience these kinds of problems later on in their careers. The survey was sent out to fourth-year undergraduate mechanical and aerospace engineering students at the University of Virginia, and 24 responses were received. 37.5% of respondents said they would be "very uncomfortable" or "somewhat uncomfortable" if they were asked to design and build weapons for the United States military. 20.8% said they would not even take a job that asked them to do that. In regards to the specific light attack aircraft technical design project, 42.1% of survey respondents said they are or would be "very uncomfortable" or "somewhat uncomfortable" participating in the project. It is interesting to note that the engineering students seemed more comfortable with the idea of designing weapons for the US military (37.5% said they would be uncomfortable), yet those same students were less comfortable with designing a light attack aircraft (42.1% said they would be uncomfortable). This difference could be due to specificity on the weapon, which could make it seem more real to some inexperienced young engineers, or it could be due to ideation vs actual participation. Either way, this emphasizes a key

point that was brought up in the earlier interviews: realize what you are getting yourself into before you are faced with it for the first time.

This qualitative and quantitative data was able to introduce some important aspects into the role that engineering ethics plays in the attack aircraft design project. The data was also able to emphasize some previously discussed STS frameworks, such as large technical system and actor-actant network theory. With this data, the problem was able to be analyzed with more current and relevant perspectives that allow progress and further understanding of the dilemma.

Discussion

Both of the interviews with Jimenez and Quinlan addressed the large technical system that is at play by talking about all of the system builders who share responsibility. They agreed that the ethical dilemma cannot just be analyzed from the perspective of the engineers, but from the system as whole. Ultimately, it is never one person's fault because it is not just one person's job to produce military weapons. This is an important idea to remember as an engineer and can help make people more comfortable with their potential involvement since the dilemma is shared and not weighing on just one person. Without an individual engineer, the system will still move forward and weapons will still be developed.

Among the two interviews and the survey to the students, there was also a common theme around the discussion of the banality of evil. According to Adonay Jimenez, engineers should actively think about the kind of work they are getting into and need to address and accept the problems that come with it. If the problems are too much, it should be thought about beforehand so that line of work can be avoided. Jesse Quinlan had much to say in agreement: recognize the dilemmas and decide if it is something that can be pursued. He had a personal experience with this where he became aware of a personal moral dilemma in his work and decided not to pursue it further. However, Quinlan also said that after acknowledging the dilemma, you must either reconcile the potential impacts or move to detach yourself from it and focus more on the job of an engineer: to solve the technical problems at hand. This detachment can produce a banality of evil where the evil is committed without thought and without malicious intent. Furthermore, many of the students in the survey were not very comfortable with the idea of designing a light attack aircraft even though many of those same students had to design one for the senior capstone project. This again shows a banality of evil and shows the students practicing the idea that Jesse Quinlan explained: the necessity to remove the emphasis on the harm that could be done and instead focus on the good that can come from the project.

Conclusion

Based on previous literature and research, and based on recently obtained research and data, it can be concluded that all people view ethics differently, especially when it involves engineers' role in society. It is mostly accepted and agreed upon that engineers are supposed to do good for society, but there is much debate as to how that can, and should, be achieved. Some people believe doing what's truly good and right should not come at the expense of others. By causing harm, society is ultimately not benefitting. However, other people believe that sometimes the ends can justify the means. If harming others in a defensive, or even an offensive, way can benefit the majority of people, then the engineers are fulfilling their role by doing good for society. Luckily, no one is forced to participate in something that they view as unethical. Each person who chooses to work for the nation's defense, by joining the military or by working as a civilian engineer, must accept and understand the role they are taking on. Those who would be uncomfortable with their involvement in militaristic technologies should not put themselves in that position. For myself and the other students who are designing a light attack aircraft as our senior capstone design project, we are able to come to terms with how we view this ethical dilemma before we have to be faced with it in our careers. Moving forward, this complex problem should be reflected upon by every engineer not only so that they can think about what they're comfortable with, but also to provide awareness to the implications of their work so they don't have to regret a thoughtless decision later in life.

References

Ahn, J., & Berkeley. (2014, December 20). The Ethics Choice of a Scientist: The Example of Robert Oppenheimer.

Bildagentur, P. (2020, August 5). Bombing of Hiroshima and Nagasaki. Retrieved September 10, 2020, from https://www.history.com/topics/world-war-ii/bombing-of-hiroshima-and-nagasaki

Davis, G. (2008). A Study in Engineering and Military Ethics.

Davis, M. (2015). Ethical Issues in the Global Arms Industry: A Role for Engineers. Ethical Dilemmas in the Global Defense Industry Conference.

Fichtelberg, A. (2006). Applying the Rules of Just War Theory to Engineers in the Arms Industry.

Florman, S. C. (1989). The civilized engineer. New York, NY: St. Martin's Press.

Gilmer, P. J., & DuBois, M. (2002, April 8). Teaching social responsibility: The Manhattan project. Commentary on "The Six Domains of Research".

J. Robert Oppenheimer's Interview. (n.d.). Retrieved October 5, 2020, from https://www.manhattanprojectvoices.org/oral-histories/j-robert-oppenheimers-interview

Lieber, K. A. (2008). War and the engineers: The primacy of politics over technology. Ithaca: Cornell University Press.

Light Attack/Armed Reconnaissance. (2020, August 27). Retrieved September 09, 2020, from https://en.wikipedia.org/wiki/Light_Attack/Armed_Reconnaissance

Mindell, David. "The science and technology of World War II." 2009. Science & Technology of World War II, National WWII Museum. Republished from https://www.ww2sci-tech.org/essays/essay2.html

National Society of Professional Engineers. (2019). NSPE Code of Ethics for Engineers.

The Editors of Encyclopaedia Britannica. (2020, September 10). Manhattan Project. Retrieved September 12, 2020, from https://www.britannica.com/event/Manhattan-Project

Unger, S. H. (1994). Controlling technology: Ethics and the responsible engineer (Second ed.). New York, NY: Wiley & Sons.

Veach, C. M. (2006, July 01). There's No Such Thing as Engineering Ethics.

Williams, K. B. (2016, August 10). The Military's Role in Stimulating Science and Technology: The Turning Point. Retrieved September 09, 2020, from https://www.fpri.org/article/2010/05/the-militarys-role-in-stimulating-science-and-technology-the-turning-point/