Drones: Their Ethical, Moral, and Health Implications

A Major Qualifying Project (MQP)
submitted to the faculty of Worcester Polytechnic Institute
in partial fulfillment of the requirements for the
degree of Bachelor of Science

By:
James Ralph

Submitted:

Approved By:
Professor Peter Hansen, Advisor
International & Global Studies Department
phansen@wpi.edu

Abstract

The first drone was designed and tested by the British during WW1. Since then the designs and capabilities of drones have evolved exponentially. Modern drones use various types of engines and engage in various operations and missions in both civilian and military applications. One type of engine used by drones is a Rotating Cylinder Valve Engine (RCV). Our six-person team worked to research, design, and begin manufacturing an RCV Engine

Along with explaining the research, design, and manufacture of the RCV engine, this paper will undertake a deep evaluation of the global impact of drones with respect to military operations. Drones allow for a new type of warfare that has protected countless soldiers' lives but is this benefit outweighed by the moral, ethical, and health concerns surrounding drone usage? This paper evaluates the uses of drones by the United States, Russia, and Ukraine. From these examples, we are able to create a basic understanding of how drone warfare affects civilians’ and soldiers' lives.

Table of Contents

List of Figures

Acknowledgments

I would like to thank a few people for their tremendous support throughout this project.

First, I would like to thank my advisor, Professor Peter Hansen, for his guidance. The time he dedicated to supporting me and this project has been monumental. Throughout this project, Prof. Hansen has provided me with immensely helpful advice on how to tackle this project due to the vastness of the project on the possibilities of drone uses and their effects. His help and feedback allowed for a more impactful project.

Second, I would like to thank the 5 other people who assisted with the "Mechanical Engineering Major Qualifying Project" section of this project; Jack Parker, Devin Patel, Jiwon Shon, Molly Vincent, and Michael Zembruski. Without these students, I would not have been able to complete this project because parts of Section 2.0 Background and 3.0 Requirements and Design for Manufacturing an RCV Engine are adaptations from the RCV MQP Paper. I would also like to thank my Mechanical Engineering Major Quantifying Project advisor, Professor Selçuk Güçeri, whose expertise with engines greatly helped the design and manufacturing of the RCV engine.

Finally, I would like to thank any other individuals not mentioned for their help and dedication in assisting me in this project. Without their help, I would never have been able to complete this project.

1.0 Introduction

The first part of this project revolves around the development and manufacture of the RCV Engine; or rotating cylinder valve engine. The RCV engine was originally designed by Charles Yale Knight. His work created the concept of a rotating-cylinder engine design. This initial design has seen various evolutions and is now utilized in many modern applications. The fascinating part of his design was incorporating the simplicity and compactness of the 2-stroke engine with the mechanical advantages of the 4-stroke engine.

The second part of this project revolves around the implications of drone warfare for the world. Drones are a rather new technology, heavily used by the United States military and becoming used more and more by other countries. The increased use of drones in warfare raises questions about the moral, ethical, and mental health effects of drone use in warfare, particularly its implications for civilians. By looking at the uses of drones by the United States, Russia, and Ukraine, we analyze the complicated questions around drone warfare. Specifically, are drones inherently unethical? What benefits do they provide to the battlefield? When have they been used unethically? How do operators navigate the disconnect created by engaging in remote combat? And what are the possible mental health implications of drone warfare on the operators?

2.0 Background

2.1 Drones

2.1.1 History

The definition of a drone from the Merriam-Webster dictionary is “an uncrewed aircraft or vessel guided by remote control or onboard computers.”.[1] The first unmanned aerial was developed by the British during WWI when they created a small radio-controlled airplane. While this was the first iteration of drone technology, there have been many improvements to the first working design. In the modern day, drones range from small drones that can be bought at most large retail stores for a few hundred dollars and controlled from a smartphone; to large military drones, like the MQ-9 Reaper, costing upwards of $30 million dollars and can be remotely controlled from halfway across the world.[2]

2.1.2 Engines

Due to the many different sizes and shapes of drones, there are various ways of powering drones. Some smaller drones are electric-powered with a battery. Most of the larger drones are powered by piston-driven combustion engines. A large impact on the effectiveness of drones is their ability to be compact but still deliver the power vital for flight. Because of this, the thrust-to-weight ratio is a vital design specification engineers must take into account when designing and testing new drones. This leads engineers to opt for an engine that can provide a higher thrust-to-weight ratio. Often these are engines that are more compact than standard engines but able to

[1] “Definition of DRONE,” accessed April 15, 2024, https://www.merriam-webster.com/dictionary/drone.
[2] “General Atomics MQ-9 Reaper,” in Wikipedia, April 11, 2024, https://en.wikipedia.org/w/index.php?title=General_Atomics_MQ-9_Reaper&oldid=1218452276.

provide large amounts of power. Some engines that are able to do this are Rotary Engines, Wankel Engines, and Rotary Cylinder Engines.

2.2 Rotating Cylinder Engines (RCV)

2.2.1 Applications of RCV Engines

RCV engines are engines built with a single combustion chamber containing a rotating valve with the ability to control the gas exchange process. RCV engines use a simplistic 2-stroke engine with the mechanical benefits of a 4-stroke engine. The axial piston rotates at twice the speed of the internal cylinder. The air intake, air exhaust, fuel intake, and ignition all take place through a single hole during two full rotations of the piston. The RCV-90 (0.90ci or roughly 15cc output engine) presents notable advantages over conventional camshaft-valve engines. This simplistic design allows for fewer moving parts, resulting in better reliability and reduced maintenance. The engines' compact cone shape also allows efficient utilization of space. Minimizing weight is specifically important for aircraft due to the thrust-to-weight ratio which is vital for flight. RCV engines are used in various types of applications, such as RC airplanes, models, and drones. Some examples of these applications are seen in Figures 1 and 2.

Figure 1: Single Prop Model Airplane[3]

Figure 2: Unmanned Surveillance Drone[4]

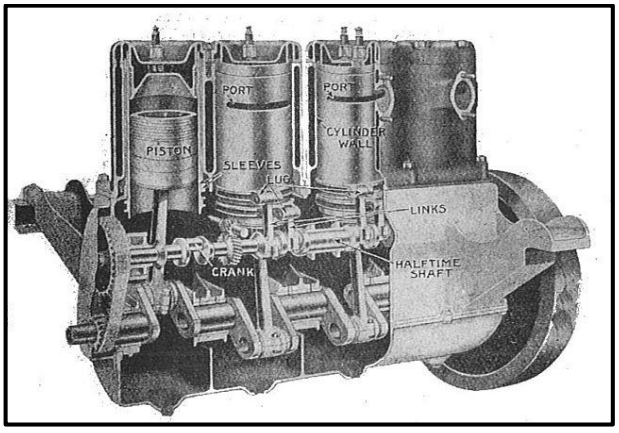
The simplicity in the design of the RCV engine makes them ideal candidates for use in many unmanned aerial vehicles (UAV). Most notably, RCV engines and adaptations of RCV

[3] Dan Pimentel, "The Perfect Single-Engine Piston Airplane for You," FLYING Magazine (blog), January 12, 2021, https://www..com/2020-buyers-guide-perfect-single-engine-piston/.
[4] maritimecyprus, "EMSA Deploys Drones in Italy for Maritime Surveillance | MaritimeCyprus," April 5, 2023, https://maritimecyprus.com/2023/04/05/emsa-deploys-drones-in-italy-for-maritime-surveillance/.

engines are used by militaries due to the unique benefits they offer. An example is a company in England actively exploring the incorporation of RCV engines into unmanned drones for a multitude of applications, underscoring the engine's adaptability and potential for innovation in emerging technologies.[5]

2.2.2 History of RCV Engines

The first design of the RCV engine was developed by Charles Yale Knight in 1905. The RCV engine utilizes a rotating cylinder instead of the conventional poppet valves to control the intake, exhaust, and aligning ports to regulate air and fuel flow.[6] Knight's goal for this innovative engine was to reduce noise and vibrations from the engine's valves and improve fuel and power delivery.



[5] "RCV Engines Home | Specialists in Multi-Fuel Engine Technology," RCV Engines Ltd, accessed April 15, 2024, https://rcvengines.com/.
[6] "Jaguar Daimler Heritage Trust," accessed April 15, 2024, https://www.jaguarheritage.com.

Figure 3: Knight Engine[7]

The contribution of Knight extended far beyond this initial design of the poppet valve engine and the cross-rotary engine by Roland C. Cross. The Cross Rotary Engine was originally designed to be a motorcycle engine fitted with a Cross rotary valve cylinder running a compression ratio of 10.5:1 showcasing the versatility and potential of alternative engine configurations.[8]

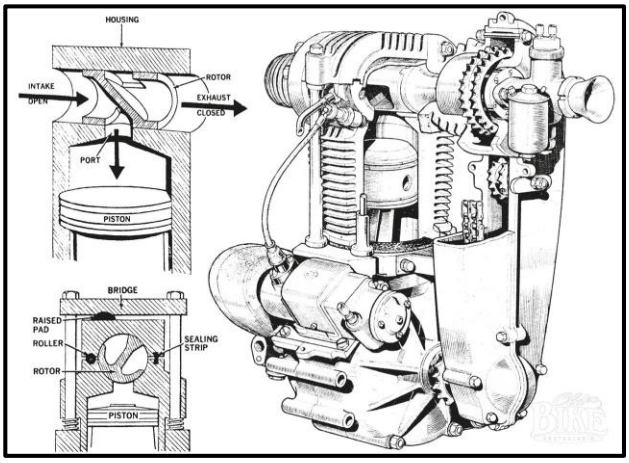


Figure 4: Cross Rotary Engine[9]

The RCV Engine which is modeled off these prior engines is a rotary-valve four-stroke engine. RCV Engines has long been known for its advantages over traditional poppet valve designs, offering improved performance and efficiency.

[7] Cyril James, "History of Cross, Taken from an Illustrated Presentation by Rodney Cross," September 17, 2015.
[8] Ibid
[9] Ibid

3.0 Requirements and Design for Manufacturing an RCV Engine

3.1 Methods

For this project, the team first took apart an RCV-90 engine. Once taken apart the team measured and reverse-engineered our design on SolidWorks. Once we had a Solidworks design, we used Fusion 360 to create a toolpath for machining. The team tested different sizes and materials to find what would be best for our RCV engine model.

3.2 Computer-Aided Design

To begin, the team used Computer-Aided Design (CAD) to create the basic model of the RCV-90 engine. This enabled a deep understanding of the specific steps and components and the mechanisms of the inner workings. At this point, the team broke up into three different groups, each with two people, to begin to model the engine. The two-person teams model the inner and outer crankcase, the cylinder and shell, and finally all the minerals of the engine.

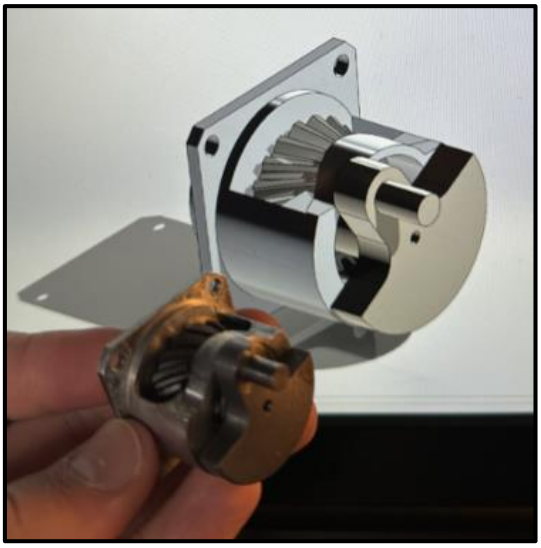


Figure 5: RCV-90 Inner Crankcase CAD

From the CAD model, we were able to understand how the RCV engine worked and utilized the working assembly tool to understand how our engine would work. Each member of the team needed to have a comprehensive understanding of the engine to allow for proper design of the engine.

The large bevel gear the team decided to use required modifications to allow it to work in our RCV engine. The main thing that needed to be modified was making a large hole to allow the piston to operate without colliding with the gear. The second major modification was a way to connect the gear to the cylinder, the team opted for 6 holes to allow bolts to fasten the gear to the cylinder.

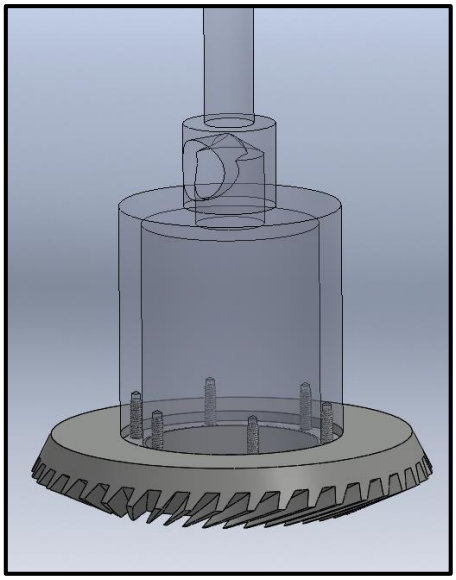


Figure 6: Inner Cylinder and Gear Attachment Detail View

Once the design for the gear and cylinder were finalized, the team moved to the design of the inner crankcase. This part uses a small bevel gear mounted to the crank rod to allow for proper timing of the engine. There are also two ball bearings attached to the crank rod to allow for smooth operation. The crank rod also needed to be modified so it would fit into the bevel gear and the ball bearings.

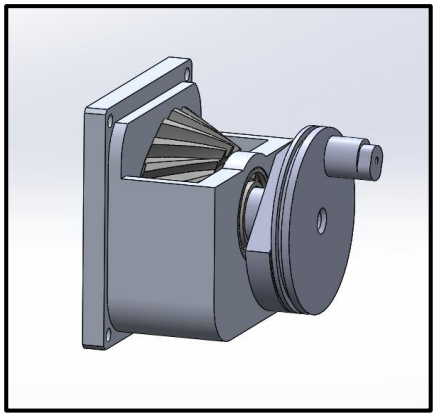


Figure 7: Inner Crankcase Assembly

The team then moved on to design the outer crankcase. This part needed to house both the large bevel gear and the entirety of the inner crankcase. This housing is pivotal for the proper operation of the engine. If any part of the crankcase housing is off the engine will not operate.

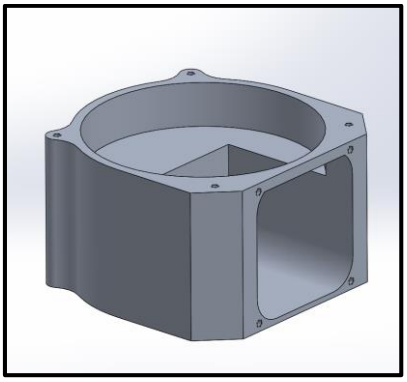


Figure 8: Outer Crankcase Component

The last parts of the design phase were the cylinder and the cylinder shell. The cylinder shell was the easier of the two parts because as long as the shell had proper spacing between the

cylinder the engine would operate. The team designed fins on the shell to allow for proper heat dissipation of the engine. The more complicated part was the cylinder where the combustion would take place. The team, with assistance from Washburn Shops staff, designed a cylinder that would allow for the piston to move smoothly as well as proper combustion.

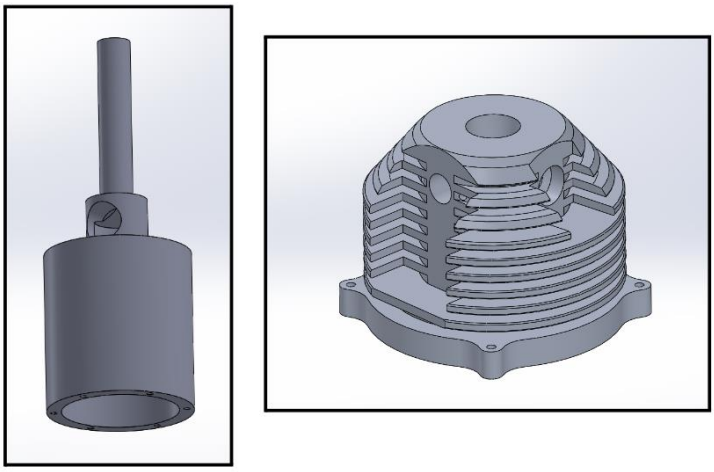


Figure 9: Inner Cylinder (left) and Outer Cylinder Shell (right)

Once the design of each part was completed, an assembly was created of all of the parts to study the motion, fit, and functionality of each component in the engine, as well as the overall mechanism.

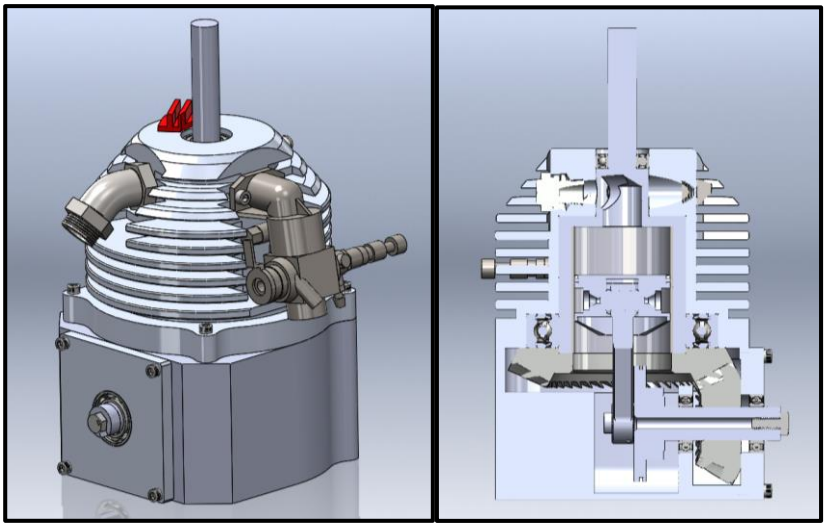


Figure 10: Full Engine Assembly (left) and Full Engine Cross-Section View (right)

3.3 Computer Aided Machining

The team decided to use Fusion 360 as the Computer Aided Machining (CAM) program to machine our respective parts. The three basic machining operations used were milling, basic turning, and live turning. The inner crankcase, outer crankcase, and large bevel gear were machined using milling operations. The Crankshaft, Combustion Cylinder, and Heatsink were machined using turning operations.

3.3.1 CAM Milling Operations

To create the CAM operations, first, the team imported the CAD design for the engine into Fusion 360. For any internal machining of the piece, the team used the 2D pocketing operations, adaptive clearing operations, contour operations, facing operations, and drilling operations.

(Figure 11) The team selected the largest possible tool that could effectively complete the operations. Selecting the largest tool enabled us to cut down on machining time and minimize the possibility of breaking the tool during the operation. Although the CAM program is able to automatically generate the tool path, the team still needed to make adjustments to ensure a successful machining process. The first adjustment made was importing the proper feeds and speeds rates for the tool based on the materials. Because we were using aluminum and steel stock, we needed to increase the feeds and speed rates for the aluminum and decrease them for the Steel. (Figure 12) The second adjustment the team made was programming multiple depths for each operation. By using multiple depths, the tool incrementally cuts into the stock.

Although this increases the overall machining time, it greatly diminishes the possibility of damaging the tool. (Figure 13) The last adjustment the team made to the milling operations was to cut the stock. When CAM generates a tool path it leaves some fraction of the stock and the intended dimensions created in CAD. By cutting the Stock material, the tool will cut the intended dimensions exactly.

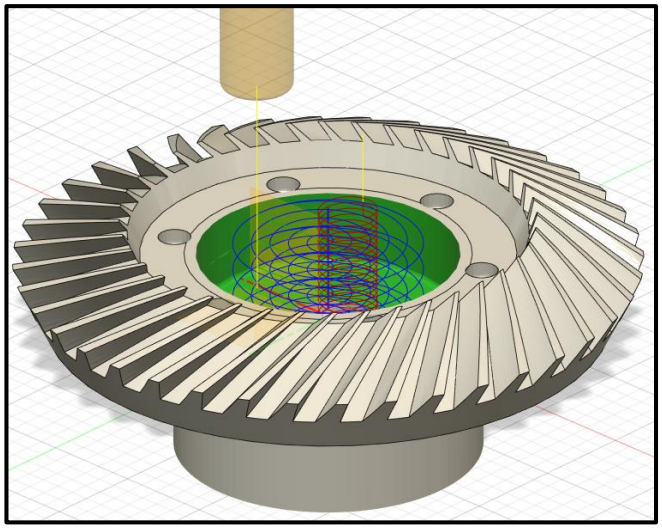


Figure 11: Adaptive Clearing Operation Tool Path Generated in Fusion 360 for the Large Gear

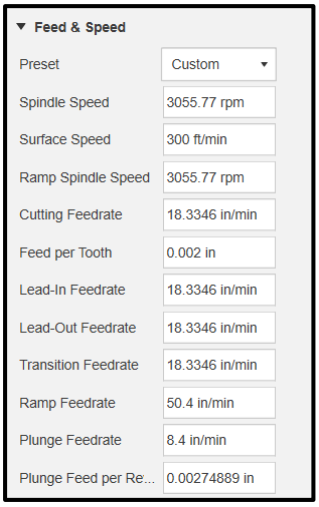


Figure 12: Custom Feeds and Speeds for Milling Operation on the Steel Bevel Gear

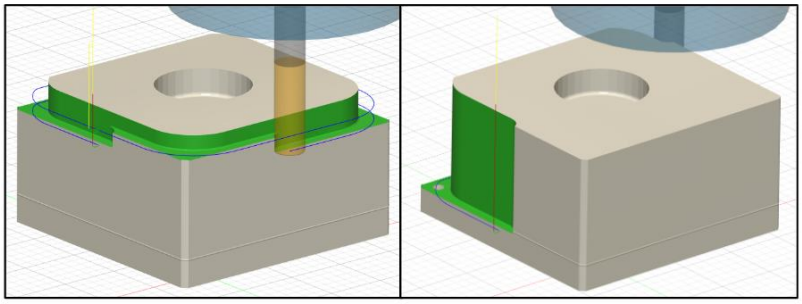


Figure 13: Comparing Using Multiple Depth (left) and Not Using Multiple Depth (right)

3.3.2 CAM Turning Operations

To create the Turning Operations for the Crankshaft and the Outer Shell, the team imported the CAM designs into Fusion 360. Once imported we selected a cutting to cut down the diameter of the crankshaft arm. (Figure 14) After the CAM software generated the operation, we changed the feed rate and the spin rate to machine the steel crankshaft. Finally, the team created a finishing operation to cut down the excess stock and leave a smoother surface. The second turning operation was a live tooling operation. In customary turning operations the piece being machined spins and the tool is stationary but in live tooling the tool also spins. The live tooling operation was used to machine the combustion cylinder and the outer shell. To create the CAM program for live tooling the staff at Washburn Laboratories requested they be allowed to create the program to ensure the machine does not break during operation.

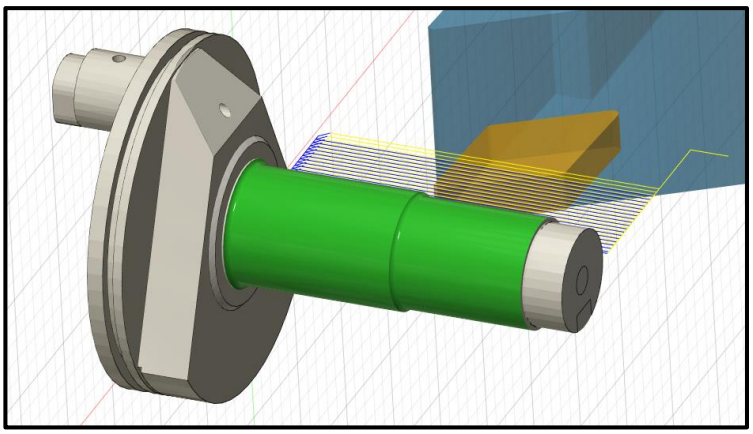


Figure 14: Turning Operation Generated in Fusion 360 for the CrankShaft

After creating the CAM program to machine the parts, the team met with Teaching Assistants and Lab Monitors at Washburn Laboratories. The staff helped review the CAM and make suggestions on increasing dimensions, changing tools, changing milling operations, and finally helping and supervising the actual machining of our engine. They also notified the team of the specific machine tools we would need to purchase to complete the more complex and specific operations.

4.0 Global Impact of Drones

In the past 20 years, the use of drones has increased exponentially. Their ability to open a whole new aspect of warfare has changed the way warfare is conducted. The world will never revert to older warfare strategies. This opens a new avenue of concern. How does drone warfare affect ground combat? How do they affect civilians? What are the ethical concerns of drone warfare? Ultimately, what are the overarching global impacts of drone warfare?

4.1 Overview

Drones have been developed or used by militaries across the world since before the First World War. In recent years, drones have seen drastic technological advancements that have allowed both large and small armies to utilize their advantages.

4.2 The War on Terror

On September 11th, 2001, two passenger planes crashed into the Twin Towers in New York City (Figure 15), a 3rd crashed into the Pentagon, and the 4th (believed to be heading to the White House) crashed in a field in Pennsylvania. All the planes were hijacked by terrorists from the Al Qaeda terrorist group. In total around 3000 people were killed in these attacks which thrust the United States into a 20-plus-year war against terrorism.[10]

[10] "September 11 Attacks: Facts, Background & Impact," HISTORY, August 9, 2023, https://www.history.com/topics/21st-century/9-11-attacks.

Figure 15: Smoke coming out of the Twin Towers after being struck by airplanes before their collapse.[11]

4.2.1 United States Drone Uses in Warfare

During the War on Terror, one of the United States frequently used drones was the "Predator Drone". (Figure 16)[12] In April 2001, the United States had 15 Predator Drones. Ten years after 9-11 the United States had nearly 11,000 UAVs in service.[13] The Predator Drone had the ability to remain airborne for up to 40 hours. It could be equipped with hellfire missiles, which are very powerful but also have a smaller blast area which allows a more accurate payload precision without the risk of unintentional casualties.[14] Along with the predator drone, the United States used the RQ-7 Shadow and the RQ-2 Pioneer.[15] Both are smaller than the Predator Drone. The United States currently has countless active drone types in use in all areas of military operations.

[11] "September 11 Hijackers Fast Facts | CNN," accessed April 15, 2024, https://www.cnn.com/2013/07/27/us/september-11th-hijackers-fast-facts/index.html.
[12] "The Predator, a Drone That Transformed Military Combat," March 9, 2018, https://airandspace.si.edu/stories/editorial/predator-drone-transformed-military-combat.
[13] Ibid
[14] Ibid
[15] Ibid

Figure 16: United States Air Force Predator Drone.[16]

4.3 Russia-Ukrainian War

On February 22, 2022, Russian military forces launched a full-scale invasion of Ukraine.[17] The attack was an attempt to overthrow the Ukrainian government, led by President Volodymyr Zelensky.[18] It is widely believed that the goal of the invasion of Ukraine was fueled by Russian President Vladimir Putin's vision of recreating the USSR. Many military and political analysts expected the much smaller country of Ukraine to fall rather quickly against the Russian invasion but after a failed initial assault, the Ukrainians were able to push back and have been entrenched in fighting Russia for the last 2 years. Many countries have sent aid to Ukraine and the United

[16] "Predator RQ-1 / MQ-1 / MQ-9 Reaper UAV, United States of America," accessed April 15, 2024, https://www.airforce-technology.com/projects/predator-uav/.
[17] "Key Moments in the Russia-Ukraine War: A Timeline - The New York Times," accessed April 15, 2024, https://www.nytimes.com/article/ukraine-russia-war-timeline.html.
[18] Ibid

Nations has imposed various sanctions on Russia for their actions.[19] The Russian Defense Minister has said there have only been 6,000 Russian casualties to date but the head of the British armed forces said it was closer to 50,000.[20] From unclassified United States Congress documents it is estimated that 315,000 Russian personnel have been killed or injured.[21] The number of deaths of the Ukrainian military is also widely disputed between Russia and Ukraine but the United States Pentagon estimates the highest number of 131,000 casualties during the war.[22]

[19] "'High Time for Peace', UN Chief Says, as Russia's Full-Scale Invasion of Ukraine Enters Third Year | UN News," February 23, 2024, https://news.un.org/en/story/2024/02/1146912.
[20] "How Many People Have Died in Russia-Ukraine War?," accessed April 15, 2024, https://www.newsweek.com/how-many-dead-russia-ukraine-war-update-troops-civilians-1864034.
[21] Ibid
[22] Helene Cooper et al., "Troop Deaths and Injuries in Ukraine War Near 500,000, U.S. Officials Say," The New York Times, August 18, 2023, sec. U.S., https://www.nytimes.com/2023/08/18/us/politics/ukraine-russia-war-casualties.html.

Figure 17: Progressive Map of the Ukraine War[23]

4.3.1 Russia Drone Uses in Warfare

Russia's utilization of drones in its war with Ukraine is extensive. The Russian military utilizes many different types of drones, one is the Kamikaze Drone. (Figure 19) These drones are relatively cheap; costing only about $20,000.[24] These drones are also relatively simple; they are basically missiles that can circle an area, and ~~which~~ will only attack when they receive the command to do so. The conflict has now entered its second year. With each day and every offensive, the Russian military is using more and more drones. On January 1st, 2024, Russia launched drones into Ukraine.[25] Ninety Shahed-type drones were sent into Ukraine in response to attacks on the Russian city of Belgorod which was reported to have killed more than 2 dozen people and injured over 100 more.[26] In condemning the attack on Belgorod, Putin said, "Of course, we can hit public squares in Kyiv and in any other Ukrainian city." He went on to say, "I understand — I'm boiling with rage — but do we need to hit civilians? No. We are hitting military targets, and that's what we will keep doing."[27]

Formatted: Indent: First line: 0.5"

Although this seems reasonable, on multiple occasions Russian forces have used drones to hit civilian targets. On December 29th, 2023, one day before the attack on Belgorod, Russian forces used 158 drones and missiles to launch an attack on the Ukrainian western city of Lviv. During the attack on Lviv, many of the Russian drones struck residential buildings and schools.[28] The Russian tactic of utilizing a large number of drone strikes on military and civilian targets, may

[23] "Ukraine in Maps: Tracking the War with Russia," accessed April 15, 2024, https://www.bbc.com/news/world-europe-60506682.
[24] "How Are 'kamikaze' Drones Being Used by Russia and Ukraine?," July 24, 2022, https://www.bbc.com/news/world-62225830.
[25] Associated Press, "Russia Launches Record Number of Drones in Ukraine, and Putin Says Moscow Will Intensify Its Attacks," Los Angeles Times, January 1, 2024, https://www.latimes.com/world-nation/story/2024-01-01/russia-launches-record-number-of-drones-in-ukraine-and-putin-says-moscow-will-intensify-its-attacks.
[26] Ibid
[27] Ibid
[28] "How Are 'kamikaze' Drones Being Used by Russia and Ukraine?," July 24, 2022, https://www.bbc.com/news/world-62225830.

be a sound military tactic, brings into question ethical issues of warfare and implicates the possibility of war crimes being committed via drone use.

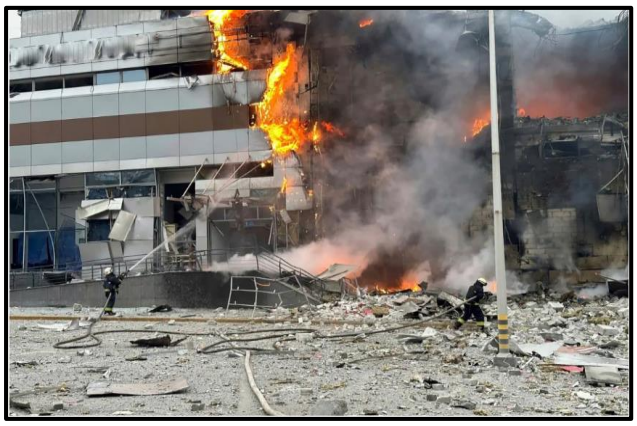
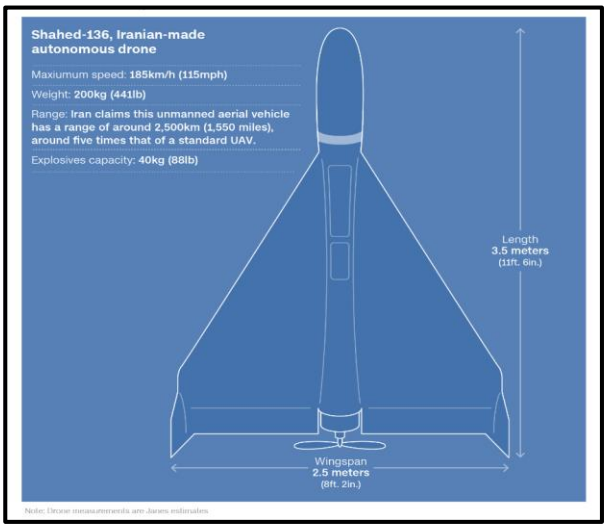


Figure 18: Firefighters Working to Extinguish a Fire Begun by a Drone Strike in Lviv.[29]



[29] "Russia Unleashes Biggest Air Attack on Ukraine since Start of Full-Scale Invasion | CNN," accessed April 15, 2024, https://www.cnn.com/2023/12/29/europe/ukraine-russia-airstrikes-intl-hnk/index.html.

Figure 19: Basic Schematics of the Kamikaze Drone.[30]

4.3.2 Ukraine Drone Uses in Warfare

Ukraine has also utilized drones on many occasions as a tactical resource to target Russian military targets. The most common drone the Ukrainian military uses is the DJI Mavic 3 which costs around $3000. (Figure 20)[31] This drone is a small 4-propeller remote-controlled aircraft. It is battery-powered and has a radio transmission range of 15 km and multiple camera/video capabilities. It is utilized because it is relatively cheap but very sturdy and durable. The Ukrainian military uses these drones for reconnaissance missions and tactical fire missions. For tactical fire missions, often the military will attach an explosive to the bottom of the drone, fly it to the intended target, drop the explosives, and fly the drone back to the user.

[30] "'Kamikaze' Drones Are the Latest Threat for Ukraine. Here's What We Know | CNN," accessed April 15, 2024, https://www.cnn.com/2022/10/17/europe/kamikaze-drones-explained-update-intl/index.html.
[31] "What Wedding Drones over Ukraine Can Tell Us about the War | Wilson Center," accessed April 15, 2024, https://www.wilsoncenter.org/blog-post/what-wedding-drones-over-ukraine-can-tell-us-about-war.

Figure 20: DJI Mavic 3 Drone Predominantly Used by Ukraine[32]

5.0 Ethical Concerns of Drone Warfare

There is no dispute that drones give an enormous advantage on the battlefield. They allow a more real-time understanding of the events on the ground and offer the ability to provide a large payload when needed. However, some consider their uses to be unethical.

5.1 Military Ethics

Ethics is a major consideration that all people should be educated on to allow them become a better person and live a life that is not only better for others but healthier for them. Military ethics is a major concern for Officers in the United States military because of the vast responsibility they have in the course of their job and the serious consequences (physical, mental, and political) that their choices can cause around the world. To ensure all military officers have a proper understanding of ethics, all Academy Students, Reserve Officer Training Corps (ROTC) Candidates, and Officer Candidates (OCS) must participate in ethical training courses. The specific ethics training referred to in this paper is the Ethics Course taught to Naval ROTC candidates in their senior year of ROTC before commissioning as Naval Officers.

5.1.1 U.S. Naval Reserve Officer Training Corps Ethics Course

[32] "DJI Mavic 3 Multispectral With Fly More Kit – Agri Spray Drones," accessed April 15, 2024, https://agrispraydrones.com/products/dji-mavic-3-multispectral.

At the beginning of the Naval ROTC ethics course, the students are taught about the importance of having basic ethical values that can be improved upon throughout their naval career and their lives. As part of the course, students are taught about "moral injury." Moral injuries commonly occur when a person does an action that goes against their morals which leads them to have cognitive dissonance.[33] When a person experiences cognitive dissonance there are two ways to resolve it. David Luban, a professor at Georgetown University,[34] describes these as the "High Road" and the "Low Road'. Luban lays out these two trains of thought when it comes to making decisions and how that affects your Ethical values. The first is the Low Road. (Figure 21)[35] In the low road, a person's action causes them moral injury, and instead of self-reflection on what specifically caused them the injury, instead they rationalize their action. This leads a person to, over time, corrupt their morals and ultimately allow a person to live a less moral life. The alternative choice is the High Road (Figure 22).[36] On the high road, a person's action causes moral injury, and the person does self-reflection on why they received the injury. Then, instead of rationalizing their action, they correct their action and try to improve all their future actions. This allows a person to continue to improve their morals and become a more moral person.

[33] Dr. Robert Herbert, Jr. CAPT, USN (RET) and Dr. Marc LiVecche, eds., Ethics & Moral Reasoning for Naval Leaders, 1st ed. (Pearson Education, Inc, n.d.).
[34] "David J. Luban," accessed April 17, 2024, https://www.law.georgetown.edu/faculty/david-j-luban/.
[35] Dr. Robert Herbert, Jr. CAPT, USN (RET) and Dr. Marc LiVecche, eds., Ethics & Moral Reasoning for Naval Leaders, 1st ed. (Pearson Education, Inc, n.d.).
[36] Ibid

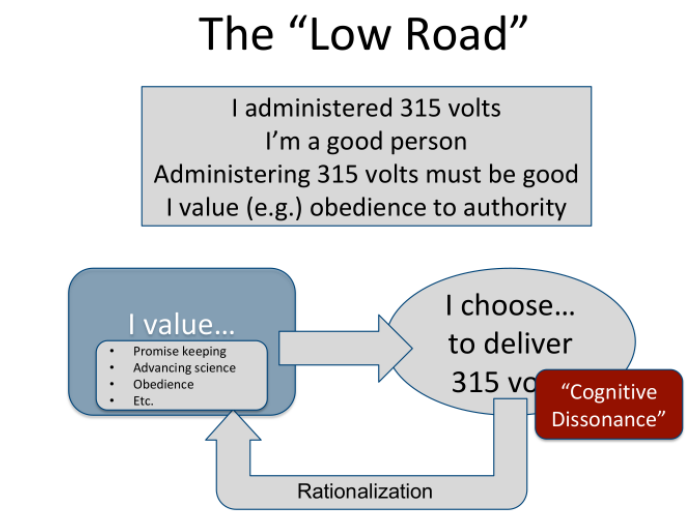
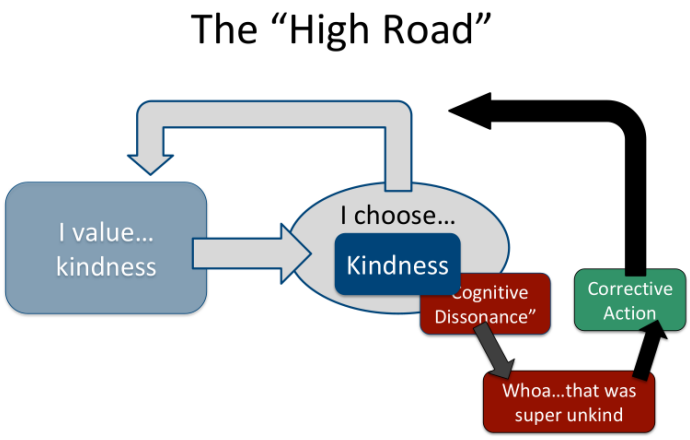


Figure 21: Luban's Low Road[37]



[37] Dr. Robert Herbert, Jr. CAPT, USN (RET) and Dr. Marc LiVecche, eds., Ethics & Moral Reasoning for Naval Leaders, 1st ed. (Pearson Education, Inc, n.d.).

Figure 22: Luban's High Road[38]

ROTC students taking the military ethics course also learn about the Moral Deliberation Road map. (Figure 23)[39] This road map helps people visualize the thought process a person should use when making a moral decision. There are 4 specific parts a person needs to consider when using this map. The four are Constraints, Consequences, Special Obligations, and Character.

First, when analyzing the Constraints on a decision it is important to think about human dignity, natural human rights, and a person's responsibility to honor those rights.[40] An example of this is a person's right not to be killed. It is universally understood that a person has a basic human right to not be killed for no reason.

Second, there are Consequences. This concept is a little bit easier to understand at a surface level but gets more complicated when deeply analyzed. When considering the Consequences of an action there are many valid ways this consideration can be approached. One such example would be Utilitarianism. A person who is -utilitarian in their actions would choose an option that gives the best overall outcome for the majority of the people even if it harms a smaller group of people.

Formatted: Indent: First line: 0.5"

Third is Special Obligations. This is the part of the road map that is often easiest to understand. In Special Obligations, a person's decision will be affected by what relationship they feel they have toward another person or group of people. Within Special Obligations, there are three basic categories, Natural Duties, Voluntary Obligations, and Obligations of Solidarity. Natural duties are those that a person does not choose and should do. For example, not killing

[38] Dr. Robert Herbert, Jr. CAPT, USN (RET) and Dr. Marc LiVecche, eds., Ethics & Moral Reasoning for Naval Leaders, 1st ed. (Pearson Education, Inc, n.d.).
[39] Ibid
[40] Ibid

another person. Voluntary Obligations are ones that a person chooses, for example, if a person promises to give another person a ride, they now have a voluntary obligation to do so. Lastly, Obligations of Solidarity are obligations that a person feels they must do because of their relationship or perceived connection to that person or group of people. For example, a person may have an obligation of solidarity towards their family. An example of this would be if two children were drowning and a parent opts to save their drowning child over the other child. The action of the parent is not wrong, and most people would completely understand why that parent chose that course of action.

The last is Character. This is how your personal beliefs and morals affect your decision making. A person would probably not choose actions that they feel to be immoral even if everyone around them is telling them the opposite. A simple example of this would be if a lifeguard at a beach is told not to leave a certain area because of their employer's rules. A person then begins to drown outside that area and the guard decides to save the person, regardless of the restrictions placed on them by their employer. That guard's character told them they had to help regardless of the repercussions their employer may impose later.

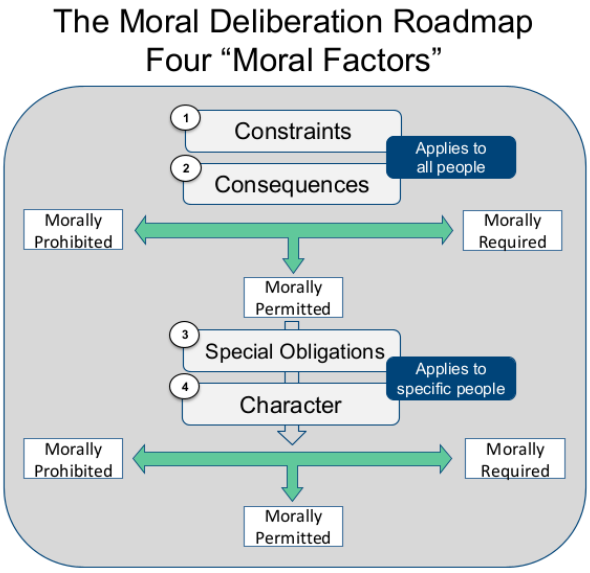


Figure 23: Moral Deliberation Road Map.[41]

5.2 Ethical Concerns Around Drones

There is no dispute that drones give an enormous advantage on that battlefield. They allow a more real-time understanding of events on the ground and offer the ability to provide a large payload when needed. However, some consider their uses to be unethical.

There are no international laws expressly prohibiting the use of drones in warfare.[42] Although there is no law specifically for drones, their missions still are regulated under the Geneva

[41] Dr. Robert Herbert, Jr. CAPT, USN (RET) and Dr. Marc LiVecche, eds., Ethics & Moral Reasoning for Naval Leaders, 1st ed. (Pearson Education, Inc, n.d.).
[42] "The Use of Armed Drones Must Comply with Laws - ICRC," 00:00:00.0, https://www.icrc.org/en/doc/resources/documents/interview/2013/05-10-drone-weapons-ihl.htm.

Convention.[43] Many countries have enacted their own laws pertaining to drones. For example, the United States has the "American Security Drone Act of 2023". This act prohibits the purchase of foreign bought drones by the federal government among other things. There are also United States laws specific to warfare that hold that the United States military must conduct themselves in an ethical, moral, and respectful way.

One serious ethical issue implicated by the use of drones in warfare is the concern about the inability of combatants to surrender. When a person is targeted by a drone, or any aerial attack, they are unable to surrender. As such, they cannot be put on trial to ascertain their guilt or innocence. Thus, in some situations, the individual will have forfeited their right to a trial. For example, if a person is actively shooting at American personnel, they have forfeited their right to not be attacked back. But this becomes more mirky when the individual is suspected of hostile intent. One real-life example is the drone strike on Zemari Ahmadi in Afghanistan, an employee of a United States-based NGO.[44] A fire-missile was launched at this car when he was driving towards this house. This attack took the lives of 10 people, including Zemari Ahmadi and his family, which included 7 children.[45] The United States said they did a scan of the area and did not find any other people in the area. They claim there was a secondary explosion which led to the deaths of the other people. Overall, the United States claims that the attack was righteous and they

[43] "Consumer Drones in Conflict: Where Do They Fit into IHL? - Humanitarian Law & Policy Blog," accessed April 15, 2024, https://blogs.icrc.org/law-and-policy/2022/03/15/consumer-drones-conflict-ihl/.
[44] Murtaza Hussain, "The Psychological Tolls and Moral Hazards of Drone Warfare," The Intercept, October 24, 2021, https://theintercept.com/2021/10/24/drone-war-books-neil-renic-wayne-phelps/.
[45] Matthieu Aikins et al., "Times Investigation: In U.S. Drone Strike, Evidence Suggests No ISIS Bomb," The New York Times, September 10, 2021, sec. World, https://www.nytimes.com/2021/09/10/world/asia/us-air-strike-drone-kabul-afghanistan-isis.html.

believed that there was an imminent threat to the American personnel at the nearby airport.[46] This would be an example of an Obligation of Solidarity, because the military personnel believed they were -protecting other United States Forces. This type of attack raises many questions about drone warfare. The situation illustrated the limits of modern information sources and some of the devastating consequences of drone warfare.

There are also examples of drone operators being told alleged misinformation when asking about an operation that looked incorrect or felt wrong. Consider the example of a former Drone Sensor Operator, Brandon Bryant.[47] Bryant remembers a time when he launched a missile at a house in Afghanistan. After the missile was launched, he saw a small child run around the corner of the building. The house was destroyed by the missile impact. When Bryant requested a review of the video recording, the off-site intelligence observer told him the creature was a dog and that the mission was a success and there was no other loss of human life.[48] A journalist Mathew Powers reported,

> "Bryant was certain it wasn't a dog… As far as the official military version of events was concerned nothing out of the ordinary had happened. The pilot 'was the type of guy to not argue with command', says Bryant. So the pilot's after-action report stated that the building had been destroyed, and the high-value target was eliminated. The report made no mention of a dog or any other living thing."[49]

[46] Matthieu Aikins et al., "Times Investigation: In U.S. Drone Strike, Evidence Suggests No ISIS Bomb," The New York Times, September 10, 2021, sec. World, https://www.nytimes.com/2021/09/10/world/asia/us-air-strike-drone-kabul-afghanistan-isis.html.
[47] Dr. Robert Herbert, Jr. CAPT, USN (RET) and Dr. Marc LiVecche, eds., Ethics & Moral Reasoning for Naval Leaders, 1st ed. (Pearson Education, Inc, n.d.).
[48] Ibid
[49] Dr. Robert Herbert, Jr. CAPT, USN (RET) and Dr. Marc LiVecche, eds., Ethics & Moral Reasoning for Naval Leaders, 1st ed. (Pearson Education, Inc, n.d.).

This example of blindly following the chain of command illustrates one of the biggest ethical issues, not only with drone warfare, but with the military as a whole. When individuals are willing to go along with a narrative, even when they know or believe something is wrong, it allows unethical actions to become acceptable as well as many other dangerous things to be accepted as the norm. This is an example of Luban's Low Road rather than his High Road. When Bryant began to experience cognitive dissonance and asked questions to try to resolve it, he was told he was fine which may have been meant to help him rationalize this action in the future.

The concern around drones is not only an American issue. There are countless instances of other countries using drones with malicious intent. The most notable is the Russian military. On numerous occasions, the Russian military has used drones to indiscriminately attack Ukraine. In some circumstances, the Russian military has actively targeted Ukrainian hospitals and non-combatants, although the Russian government denies these reports. These types of attacks are an extreme example of how drones can be used for unethical operations. These types of missions are often not accidents, they are purposely targeted knowing there will be large civilian casualties, and in some situations that is the goal of the mission, to terrorize and demoralize an enemy. Actions like these are in direct contrast to the Constraints and Special Obligations from the moral deliberation road map because in both of these subcategories, there is emphasis on the importance of natural duty and not killing innocents.

The ethics of drone use in warfare will continue to be questioned, as it should be. A military that is allowed to operate without any checks and balances is bound to repeat tyrannical histories. The most important thing a military must do is hold their soldiers and leaders accountable

and promote high morals and ethics to prevent both physical damage to civilians and to help prevent moral injury of the soldiers who are at higher risk because of the nature of their job.

6.0 Drone Operators' Mental Health

Along with the ethical concerns that come from drone warfare, there are also mental health concerns for the Drone Operators, specifically operators who pilot drones remotely. These drone operators experience immense stress for the duration of their operation, sometimes being completely unable to provide assistance but required to watch the events unfolding. They can be required to make split-second decisions or follow orders quickly and watch the repercussions of their action on a screen completely remote and outside of physician harm, but very vulnerable to mental and moral injury.

6.1 Drone Operators' Mental Health

Most drone operators are located miles from where the actual combat mission occurs. This allows the operator to be free from physical harm, but does not remove them from all dangers. Mental health is a large concern for drone operators. They are often on station for hours and are witnesses to the horrific scenes that are found on a battlefield. This can harm the operators and lead to mental health issues like Post-Traumatic Stress Disorder (PTSD). PTSD is something the United States military has been more willing to recognize and study in recent years which could affect the numbers but from Figure 24, it is evident that the cases of PTSD have been increasing with modern warfare.

Service Era	PTSD in the Past Year	PTSD at Some Point in Life
Operations Iraqi Freedom (OIF) and Enduring Freedom (OEF)	15 out of 100 (15%)	29 out of 100 (29%)
Persian Gulf War (Desert Storm)	14 out of 100 (14%)	21 out of 100 (21%)
Vietnam War	5 out of 100 (5%)	10 out of 100 (10%)
World War II (WWII) and Korean War	2 out of 100 (2%)	3 out of 100 (3%)
NOTE: The data in this table is from Veterans alive at the time of the study. As such, it does not include Veterans in any service area who have died and may have had PTSD.		

Figure 24: Military Cases of PTSD from WWII to Operation Iraqi Freedom[50]

Drone operators are different from other types of aerial attack platform operators. For example, unlike a jet attack where the plane drops its payload and then leaves the area so the pilot does not see the aftermath of the attack, drone operators see the before and after images of a drone attack target. Brandon Bryant recounts the first mission he flew where he watched a man slowly die by bleeding out. All the gory details were transmitted to the station where Bryant was operating the drones.[51] These types of experiences are textbook situations for PTSD and moral injury. People often do not think that a remote drone operator who might be hundreds of miles from the actions would be susceptible, but their experiences are just as real, and as dangerous to their mental health, as if they were on the ground watching the action in person.

[50] "VA.Gov | Veterans Affairs," General Information, accessed April 15, 2024, https://www.ptsd.va.gov/understand/common/common_veterans.asp.
[51] Dr. Robert Herbert, Jr. CAPT, USN (RET) and Dr. Marc LiVecche, eds., Ethics & Moral Reasoning for Naval Leaders, 1st ed. (Pearson Education, Inc, n.d.).

There is also a level of personal intimacy between drone operators and their targets. Unlike many other aerial attack platforms, drone operators often observe the target for a day, or more, prior to the attack. They get to see the day-to-day lives of the target which can make the attack much more personal than killing a person they have never seen prior to the attack.[52] As Colonel William Tart, who was the former head of Drone Operations at Creech Air Force Base said, "War somehow becomes personal."[53]

For the many reasons above, it is evident that the dangers drone operators experience during their duties can be just as harmful or more so to their mental health state as they are to other aerial platforms operated in person. The threat of moral injury which can lead to other mental issues such as PTSD is a real possibility and must be carefully monitored.

7.0 Civilian Impact

Although drones prevent the injury and death of countless United States servicemen every year, there are serious questions about how the increased usage of drones in warfare affects civilians in the areas targeted by the United States Military drones. The Geneva Convention is a document that countries created and signed so that the conduct of war could be as humane as possible and preserve the most lives possible. The first convention in 1906 was signed by 35 countries.[54] After World War I, it was evident that the first Geneva Convention document did not go far enough. Therefore, in 1929 new articles were added to improve upon the issues seen during

[52] Dr. Robert Herbert, Jr. CAPT, USN (RET) and Dr. Marc LiVecche, eds., Ethics & Moral Reasoning for Naval Leaders, 1st ed. (Pearson Education, Inc, n.d.).
[53] Ibid
[54] "Geneva Conventions," in Wikipedia, April 15, 2024, https://en.wikipedia.org/w/index.php?title=Geneva_Conventions&oldid=1219041254.

WWI, specifically the humane treatment of prisoners of war.[55] After WWII and the atrocities committed, new articles were added to protect non-combatant civilians in 1949.[56] Since 1949 other articles have been added.

If the Geneva Convention is supposed to protect people and lay out what is acceptable warfare, why are civilian casualties in warfare so high? Are these casualties avoidable or intentional? Does the ability to kill countless people from hundreds or thousands of miles away make it easier for people to kill the innocent? There are not currently easy answers to these questions, and the world is likely to continue to grapple with the ethical implications of drones for years to come.

7.1 Physical Damage

Since the September 11th attacks on the Twin Towers in New York, it is estimated that around 4.5-4.7 million civilians have died in war zones.[57] Despite countless United Nations Resolutions, as well as other legislation by different organizations, civilian casualties are up 87%,[58] which leads to the question, why?

As we have seen from the use of drones by the United States and Russia, either by accident or intention, civilians are being killed by drone warfare. These deaths might have been avoidable if a "boots-on-the-ground" mission had been utilized rather than a drone strike. But in-person warfare increases the possibility of military casualties by the country conducting the mission.

[55] "Geneva Conventions," in Wikipedia, April 15, 2024, https://en.wikipedia.org/w/index.php?title=Geneva_Conventions&oldid=1219041254.
[56] Ibid
[57] "Civilians Killed & Wounded | Costs of War," The Costs of War, accessed April 15, 2024, https://watson.brown.edu/costsofwar/costs/human/civilians.
[58] "Ninety Per Cent of War-Time Casualties Are Civilians, Speakers Stress, Pressing Security Council to Fulfil Responsibility, Protect Innocent People in Conflicts | Meetings Coverage and Press Releases," accessed April 15, 2024, https://press.un.org/en/2022/sc14904.doc.htm.

As seen from multiple examples -- the drone strike on Zemari Ahmadi, the drone mission described by Brandon Bryant, and the reports from the Ukraine-Russian War -- civilian casualties occur due to drone warfare, despite efforts by some militaries to prevent them. Any civilian death is a tragedy, but the mistake is compounded by a military's unwillingness to admit their mistake and by misinformation distributed on both sides of the conflict.

7.2 The Blurred Line

Another part of warfare that has changed in recent years is the line between combatant and civilian. The ability for an ordinary person to purchase items and use them for reconnaissance, sabotage, or direct attacks on military or civilian targets has led to a blurred line between civilian and combatant. The issue gets even more blurred when civilian contractors are added to the dynamic. All militaries rely heavily on support from civilian contractors and staff. This can lead to a question of who is or is not a legal target. According to the American Red Cross, all people who are not directly involved in violent operations are considered civilians.[59] That being said, a factory creating munitions or ammunition are legal targets which in turn lead to increased civilian casualties. In this modern age, the differentiation between combatant and non-combatant is inextricably blurred. Further complicating the issue is that often a decision needs to be made in a split second, but its consequences are then dissected for days or months after the event to decide if it was a righteous kill or not. Toeing this line is the responsibility of the military commanders around the world so that they can make the correct and ethical decision. This responsibility will

[59] Alexandre Faite 1, "Involvement of Private Contractors in Armed Conflict: Implications under International Humanitarian Law," Defence Studies 4, no. 2 (January 2004): 166–83, https://doi.org/10.1080/1470243042000325887.

only become more difficult as the world becomes more technologically advanced and more dangerous.

8.0 Conclusion

The technical advancement in drone warfare since WWI is extraordinary. New and powerful engines continue to be created and will continue to improve the capabilities of drones. These advancements will only elevate the possibilities of more ethical and moral issues for the militaries of the world surrounding drone use in warfare, especially as it applies to civilian casualties. It is evident that the use of drones is a massive advantage to the military. It allows for more specific reconnaissance, quicker responses to fire orders, and a reduced number of service members in physical harm's way. Drone warfare can lead to distorting the line between civilian and combatant, ethical concerns, and lead to mental health issues for the operators. These concerns are being monitored and have checks and balances but in time the more drones evolve and improve the more how warfare is conducted must evolve for the safety and betterment of the world.

9.0 Bibliography

Aikins, Matthieu, Christoph Koettl, Evan Hill, Eric Schmitt, Ainara Tiefenthäler, and Drew Jordan. “Times Investigation: In U.S. Drone Strike, Evidence Suggests No ISIS Bomb.” *The New York Times*, September 10, 2021, sec. World. https://www.nytimes.com/2021/09/10/world/asia/us-air-strike-drone-kabul-afghanistan-isis.html..

“Consumer Drones in Conflict: Where Do They Fit into IHL? - Humanitarian Law & Policy Blog.” Accessed April 15, 2024. https://blogs.icrc.org/law-and-policy/2022/03/15/consumer-drones-conflict-ihl/.

Cooper, Helene, Thomas Gibbons-Neff, Eric Schmitt, and Julian E. Barnes. “Troop Deaths and Injuries in Ukraine War Near 500,000, U.S. Officials Say.” *The New York Times*, August 18, 2023, sec. U.S. https://www.nytimes.com/2023/08/18/us/politics/ukraine-russia-war-casualties.html.

Cyril James. “History of Cross, Taken from an Illustrated Presentation by Rodney Cross,” September 17, 2015.

“David J. Luban.” Accessed April 17, 2024. https://www.law.georgetown.edu/faculty/david-j-luban/.

“Definition of DRONE.” Accessed April 15, 2024. https://www.merriam-webster.com/dictionary/drone.

“DJI Mavic 3 Multispectral With Fly More Kit – Agri Spray Drones.” Accessed April 15, 2024. https://agrispraydrones.com/products/dji-mavic-3-multispectral.

Dr. Robert Herbert, Jr. CAPT, USN (RET) and Dr. Marc LiVecche, eds. *Ethics & Moral Reasoning for Naval Leaders*. 1st ed. Pearson Education, Inc, n.d.

Faite 1, Alexandre. “Involvement of Private Contractors in Armed Conflict: Implications under International Humanitarian Law.” *Defence Studies* 4, no. 2 (January 2004): 166–83. https://doi.org/10.1080/1470243042000325887.

“General Atomics MQ-9 Reaper.” In *Wikipedia*, April 11, 2024. https://en.wikipedia.org/w/index.php?title=General_Atomics_MQ-9_Reaper&oldid=1218452276.

“Geneva Conventions.” In *Wikipedia*, April 15, 2024. https://en.wikipedia.org/w/index.php?title=Geneva_Conventions&oldid=1219041254.

"'High Time for Peace', UN Chief Says, as Russia's Full-Scale Invasion of Ukraine Enters Third Year | UN News," February 23, 2024. https://news.un.org/en/story/2024/02/1146912.

HISTORY. "September 11 Attacks: Facts, Background & Impact," August 9, 2023. https://www.history.com/topics/21st-century/9-11-attacks.

"How Are 'kamikaze' Drones Being Used by Russia and Ukraine?" July 24, 2022. https://www.bbc.com/news/world-62225830.

"How Many People Have Died in Russia-Ukraine War?" Accessed April 15, 2024. https://www.newsweek.com/how-many-dead-russia-ukraine-war-update-troops-civilians-1864034.

Hussain, Murtaza. "The Psychological Tolls and Moral Hazards of Drone Warfare." The Intercept, October 24, 2021. https://theintercept.com/2021/10/24/drone-war-books-neil-renic-wayne-phelps/.

"Jaguar Daimler Heritage Trust." Accessed April 15, 2024. https://www.jaguarheritage.com.

"'Kamikaze' Drones Are the Latest Threat for Ukraine. Here's What We Know | CNN." Accessed April 15, 2024. https://www.cnn.com/2022/10/17/europe/kamikaze-drones-explained-update-intl/index.html.

"Key Moments in the Russia-Ukraine War: A Timeline - The New York Times." Accessed April 15, 2024. https://www.nytimes.com/article/ukraine-russia-war-timeline.html.

maritimecyprus. "EMSA Deploys Drones in Italy for Maritime Surveillance | MaritimeCyprus," April 5, 2023. https://maritimecyprus.com/2023/04/05/emsa-deploys-drones-in-italy-for-maritime-surveillance/.

"Ninety Per Cent of War-Time Casualties Are Civilians, Speakers Stress, Pressing Security Council to Fulfil Responsibility, Protect Innocent People in Conflicts | Meetings Coverage and Press Releases." Accessed April 15, 2024. https://press.un.org/en/2022/sc14904.doc.htm.

Pimentel, Dan. "The Perfect Single-Engine Piston Airplane for You." *FLYING Magazine* (blog), January 12, 2021. https://www.flyingmag.com/2020-buyers-guide-perfect-single-engine-piston/.

"Predator RQ-1 / MQ-1 / MQ-9 Reaper UAV, United States of America." Accessed April 15, 2024. https://www.airforce-technology.com/projects/predator-uav/.

Press, Associated. "Russia Launches Record Number of Drones in Ukraine, and Putin Says Moscow Will Intensify Its Attacks." Los Angeles Times, January 1, 2024. https://www.latimes.com/world-nation/story/2024-01-01/russia-launches-record-number-of-drones-in-ukraine-and-putin-says-moscow-will-intensify-its-attacks.

RCV Engines Ltd. “RCV Engines Home | Specialists in Multi-Fuel Engine Technology.” Accessed April 15, 2024. https://rcvengines.com/.

“Russia Unleashes Biggest Air Attack on Ukraine since Start of Full-Scale Invasion | CNN.” Accessed April 15, 2024. https://www.cnn.com/2023/12/29/europe/ukraine-russia-airstrikes-intl-hnk/index.html.

“September 11 Hijackers Fast Facts | CNN.” Accessed April 15, 2024. https://www.cnn.com/2013/07/27/us/september-11th-hijackers-fast-facts/index.html.

The Costs of War. “Civilians Killed & Wounded | Costs of War.” Accessed April 15, 2024. https://watson.brown.edu/costsofwar/costs/human/civilians.

“The Predator, a Drone That Transformed Military Combat,” March 9, 2018. https://airandspace.si.edu/stories/editorial/predator-drone-transformed-military-combat.

“The Use of Armed Drones Must Comply with Laws - ICRC,” 00:00:00.0. https://www.icrc.org/en/doc/resources/documents/interview/2013/05-10-drone-weapons-ihl.htm.

“Ukraine in Maps: Tracking the War with Russia.” Accessed April 15, 2024. https://www.bbc.com/news/world-europe-60506682.

“VA.Gov | Veterans Affairs.” General Information. Accessed April 15, 2024. https://www.ptsd.va.gov/understand/common/common_veterans.asp.

“What Wedding Drones over Ukraine Can Tell Us about the War | Wilson Center.” Accessed April 15, 2024. https://www.wilsoncenter.org/blog-post/what-wedding-drones-over-ukraine-can-tell-us-about-war.