Military Robots: The Fighting Force of the Future

A Monograph

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This monograph examines a growing culture of casualty aversion, and its effects on the need for military robots. It makes a comparison between the growing influence and effectiveness of airpower in World War II, and the current rise of military robot interaction. The theories, capabilities, acceptance, and availability of airpower made it a vital part of Allied victory in World War II. Similarly, the early theories of military robots have come to fruition, their capabilities match current military needs, they have been accepted by the US public and military, and they are cheaper and more available than ever before. Military robots are on the cusp of creating a shift in the way war is fought, the same as airpower shifted warfare in the middle of the twentieth century. These factors, combined with the aforementioned casualty aversion, make military robots the fighting force of the future.

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Abstract

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This monograph examines a growing culture of casualty aversion, and its effects on the need for military robots. It makes a comparison between the growing influence and effectiveness of airpower in World War II, and the current rise of military robot interaction. The theories, capabilities, acceptance, and availability of airpower made it a vital part of Allied victory in World War II. Similarly, the early theories of military robots have come to fruition, their capabilities match current military needs, they have been accepted by the US public and military, and they are cheaper and more available than ever before. Military robots are on the cusp of creating a shift in the way war is fought, the same as airpower shifted warfare in the middle of the twentieth century. These factors, combined with the aforementioned casualty aversion, make military robots the fighting force of the future.

Contents

Acknowledgements vi

Acronyms vii

Figures viii

Introduction 1

Literature Review 2

Casualty Aversion Literature 2

Military Robot Literature 6

Methodology 9

Historical Case Study: Early Aviation 9

Early Aviation History 10

Early Aviation Theorists 11

The Intersection of Theory and Application 14

The Point of Effectiveness of Early Military Aviation 15

Acceptance of Military Aviation 18

Industrial Production Capacity Meets Demand 21

Conclusions 22

Modern Case Study: Military Robots 22

Robot History 22

Military Robot Theorists 26

The Intersection of Theory and Application 29

The Point of Effectiveness of Military Robots 30

Acceptance of Military Robots 32
Industrial Production Capacity Meets Demand 35
Analysis: Military Robots at the Decisive Point 36
Military Robots are Effective 36
Military Robots are Accepted 36
Military Robots are Meeting Expectations 37
The Demand for Military Robots Equals the Capabilities of Military Robots 37
System Integration of Military Robots 40
The Way Ahead: How to Incorporate Military Robots at the Operational Level 40
Support Systems for Military Robots 40
Doctrinal Integration of Military Robots 41
Military Robots Across All Levels of War 41
Potential Pitfalls 41
The Way Ahead 43
Conclusion 44
Bibliography 45

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Acronyms

AUVSI	Association for Unmanned Vehicle Systems International
AW&ST	Aviation Week & Space Technology
EOD	Explosive Ordnance Disposal
HMMWV	High Mobility Multipurpose Wheeled Vehicle
ISIL	Islamic State of Iraq and the Levant
ISR	Intelligence, Surveillance, and Reconnaissance
MOE	Measures of Effectiveness
SWORDS	Special Weapons Observation Reconnaissance Detection System
TTPs	Tactics, Techniques, and Procedures
UAV	Unmanned Aerial Vehicle
UCAV	Unmanned Combat Aerial Vehicle
UGV	Unmanned Ground Vehicle

Figures

1 The Relationship of Casualty Acceptance and Robot Need……………………………...…39

Introduction

The beginning of the twenty-first century has brought a number of changes to the art of operational military planning. The United States Army, in particular, moved from a doctrine focused on defeating a known monolithic enemy to one that espouses more flexibility and adaptability in its forces. Concurrent with this doctrinal evolution are astounding advances in technology that affect both the battlefield and the home front. Military robots are able to perform many of the duties that once took one or more soldiers to do, enabling those soldiers to stay out of harm's way. Increasing communications and media capabilities have put near-real-time battlefield video into the homes of US citizens.

This modern technology has democratized access to information about war and its casualties, while at the same time making warfare itself safer for the US soldiers. These two influences of technology have reached a point of synthesis where the technology is capable of and the citizens are adamant about minimizing human casualties. The purpose of this study is to analyze the effects of casualty aversion in the United States, examine a historical case of technology affecting the battlefield, investigate the current and near-future capabilities of military robots, and determine the timeliness of incorporating robots into operational planning and execution in a casualty averse environment.

For the purposes of this monograph the term "robot" and its variants will refer to any remotely-piloted or semi-autonomous vehicle, not necessarily a fully autonomous robot as defined by the *Oxford English Dictionary*: "A machine capable of automatically carrying out a complex series of movements, *esp.* one which is programmable." Another more specific definition is provided in a Combat Studies Institute Press publication in 2014: "Generally speaking, a military robot is most frequently defined as a system:

1. Possessing capacities of perception, communication, decision-making and action;
2. Supervised by human combatants or acting autonomously according to preset behavioral rules;

3. Capable of improving its own performance through automatic learning."[1]

Literature Review

Casualty Aversion Literature

A number of researchers have investigated United States aversion to military casualties since the Vietnam War, and their research can be divided into three periods. The first is the period of the Cold War, and includes the after effects of the Vietnam War. The second period is between 1991 and 2001, arguably a turning point in the study of casualty aversion due to the quick succession of Operation Desert Storm in 1991 and Operation Restore Hope from 1991-1994. The third period is after the terrorist attacks of September 11, 2001 and US invasion of Afghanistan that year and the invasion of Iraq in 2003 during the ongoing War on Terror.

Cold War Period

Authors from this time period were primarily affected by negative public reactions to the Vietnam War and the governmental reaction of limited engagements in the late 1970s and 1980s. The study most often cited from this period is John Mueller's 1973 book *War, Presidents and Public Opinion* in which he uses public opinion polling data from the Korean and Vietnam Wars and compares the public perception of the war effort with the perception of the President. Mueller found that support for the Vietnam War did not decline precipitously, and was actually in line with the support for the Korean War, contrary to commonly-accepted hypotheses.[2] Mueller's work stood alone for over a decade until another group took up the task of investigating casualties and public opinion.

A 1985 RAND study conducted by Mark Lorell and Charles Kelly, Jr. re-examines some of the research that Mueller did in the early 1970s. Lorell and Kelly examine the effect of

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[1] Ronan Doaré, Didier Danet, Jean-Paul Hanon, and Gérard de Boisboissel, eds., *Robots on the Battlefield: Contemporary Perspectives and Implications for the Future* (Fort Leavenworth: Combat Studies Institute Press, 2014), xvii.

[2] John E. Mueller, *War, Presidents, and Public Opinion* (Lanham, MD: University Press of America, 1985).

casualties on presidential policy during the Vietnam War. Where Mueller compared Vietnam to Korea, Lorell and Kelly used Vietnam as a case study to extrapolate potential contemporary and future political decision-making as an effect of public opinion based on casualty rates. They argue that by effectively minimizing casualties, political and military planners would have the freedom to make strategic decisions based on "intrinsic strategic, political, and moral merits" and the Congress and the President would have more options available for involvement in Third World contingencies.[3]

Modern Interwar Period[4]

During the Modern Interwar Period, casualty aversion researchers were most influenced by Operation Desert Storm in Iraq and Operation Restore Hope in Somalia. The former, with few casualties and a clear military victory against a powerful foe, was a sign that the United States could conduct large-scale military operations with little human cost. The latter, just two and a half years later, showed that under different circumstances even a score of casualties in one engagement against an unsophisticated enemy could cause public opinion to turn and force a withdrawal.

RAND researchers conducted a number of studies in the mid-1990s, two of which are important to note. In 1994, Benjamin Schwarz published *Casualties, Public Opinion, and U.S. Military Intervention: Implications for U.S. Regional Deterrence Strategies*. Like many of his predecessors, Schwarz analyzes the Korean and Vietnam Wars, but then compares them to the Persian Gulf War. He refers to casualty aversion as a supposed "America's Achilles' Heel" and posits that this is a wrong assumption, declaring that the American public was "disenchanted with

[3] Mark A. Lorell and Charles T. Kelley, Jr., with Deborah Hensler, *Casualties, Public Opinion, and Presidential Policy During the Vietnam War* (Santa Monica: RAND, 1985), 85.

[4] For the purposes of this study, the Cold War and the Global War on Terror will be treated as two distinct wars, with the decade between being referred to as the Modern Interwar Period.

the way the [Vietnam] war was conducted" but that they simply wanted to "bring more death and destruction to the Vietnamese."[5] He goes on to state that the public thought that the Persian Gulf War would be a difficult, casualty-filled struggle, but that the people still supported it. Schwarz concludes that the correlation between declining public support and withdrawal in the Vietnam War was not a causation, and was not based on the accrual of casualties over time.

Eric Larson builds on Schwarz's study, and actually contradicts many of his findings. RAND took the bold move of actually replacing Schwarz's report with Larson's, stating that Schwarz's assertions that Americans favored escalation in earlier wars "were found not to be supported by the data."[6] Larson expands the scope of his research, including World War II, Panama, and Somalia in his analysis. By looking at United States intervention in Somalia and the public backlash after the Battle of Mogadishu, Larson is able to delve deeper into the causes of public dissatisfaction with military efforts. He uses the base of public support, the changing level of commitment, and the leadership consensus and dissensus as his framework. Ultimately, Larson argues that the willingness to incur casualties is related more to the prospects for success and the expected benefits than anything else. This explains the hundreds of thousands of acceptable deaths in World War II versus the eighteen unacceptable deaths in Mogadishu.

Though RAND certainly had a stake in determining casualty aversion or lack thereof, academic researchers also studied the problem in the Modern Interwar Period. Two studies published in the *Journal of Conflict Resolution* in 1998 look at public opinion and the use of military force. Bruce Jentleson and Rebecca Britton's "Still Pretty Prudent" argues that the American public is rational and its actions can be studied using a principal policy objective

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[5] Benjamin C. Schwarz, *Casualties, Public Opinion, and U.S. Military Intervention: Implications for U.S. Regional Deterrence Strategies* (Santa Monica: RAND, 1994), 16.

[6] Eric V. Larson, *Casualties and Consensus: The Historical Role of Casualties in Domestic Support for U.S. Military Operations* (Santa Monica: RAND, 1996), iv.

method, basing use-of-force decisions on more than just irrational casualty aversion.[7] In their "War, Casualties, and Public Opinion," Scott Sigmund Gartner and Gary Segura "believe it is time to reexamine and revise" the misconception that there is an inverse relationship between casualty numbers and willingness to continue a war.[8] Much of their argument is based on discerning the difference between and benefits of studying marginal casualties versus cumulative casualties.

Global War on Terror Period

The terrorist attacks of September 11, 2001 galvanized the United States public to retaliate, no matter the cost. This sentiment held for a number of years until the War on Terror expanded to other states, (Iraq) lost focus on the original enemy, (Osama Bin Laden) and began to accumulate greater numbers of casualties. When the inevitable comparisons between Iraq and Vietnam began to surface, researchers again turned their minds toward the study of casualty aversion. The common thread of the previous two periods was that the casualty levels from the Vietnam War did not have as negative an effect as commonly thought, and post-9/11 researchers expanded upon this idea.

In the Global War on Terror period, RAND again leads the way in casualty aversion studies with a 2005 report by Eric Larson and Bogdan Savych, *American Public Support for U.S. Military Operations from Mogadishu to Baghdad*. Since Larson was a co-author of this report, it has many of the same conclusions as the 1996 report, stating that "the perceived importance of the stakes was the most important belief predicting support for the operation."[9] Larson and

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[7] Bruce W. Jentleson and Rebecca L. Brinton, "Still Pretty Prudent: Post-Cold War American Public Opinion on the Use of Military Force," *Journal of Conflict Resolution* 42, no. 4 (August 1998) 395-417.

[8] Scott Sigmund Gartner and Gary M. Segura, "War, Casualties, and Public Opinion," *Journal of Conflict Resolution* 42, no. 3 (June 1998) 278-300.

[9] Eric V. Larson and Bogdan Savych, *American Public Support for U.S. Military Operations from Mogadishu to Baghdad* (Santa Monica: RAND, 2005), xix.

Savych use a plethora of polling data to come to the conclusion that American citizens supported the war because it was important. Additionally, the polling data showed that though Americans were "'casualty-phobic' in Somalia after the firefight" they were more willing "to accept casualties in operations conducted under the GWOT than in any of the peace operations in the preceding decade."[10]

Another look at casualty aversion from the GWOT era is Hugh Smith's "What Costs Will Democracies Bear? A Review of Popular Theories of Casualty Aversion" in the Summer 2005 *Armed Forces & Society*. Smith looks at a history of casualty aversion, using a framework of national interest, strategic calculus, national policy, and social change. One thing Smith does touch upon is the concept of technology, stating that technological advances have "been pushing in the same direction" as casualty aversion.[11] Smith eventually concludes that casualty aversion is based on the aforementioned framework, and that "the further a particular war is removed from core national interests, the more the populace will be averse to casualties and the more decision-makers will seek to avoid them."[12] In other words, American casualty aversion is inversely proportional to core national interests.

Military Robot Literature

Another set of literature this study must address is on military robots and robotization of the battlefield. This literature is best divided into two categories – technical and philosophical. The technical literature deals with the scientific and practical aspects of using robots in warfare, while the philosophical deals with the ethics and morality issues that arise when using military robots. Both sets of literature have grown immensely in the past decade.

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[10] Larson and Savych, 219.

[11] Hugh Smith, "What Costs Will Democracies Bear? A Review of Popular Theories of Casualty Aversion," *Armed Forces & Society* 31, no. 4 (Summer 2005) 487-512.

[12] Smith, 492.

Technical Robotization Literature

The technical aspects of battlefield robotization are relatively straightforward. The literature runs the gamut from books written for laypeople to highly specialized, deeply technical journal articles. In the former category there are a few standouts, with the first being P.W. Singer's *Wired for War*. As a political scientist, Singer is able to keep a focus on the "so what" of robotization, and look at its greater implications, though there is an underlying despair that all of these robots are designed for war, and that humanity needs to rethink priorities, because "sadly, our machines may not be the only thing wired for war."[13]

Another good overview of military robots is *Military Robots and Drones* by Paul Springer. Springer is a historian, and his book reads almost like an encyclopedia on military robots. He includes a history, a timeline, biographical sketches, and a regional analysis of different countries' robotic capabilities. There is no thesis, per se; instead, he alludes to the need to "manage the proliferation and utilization" of military robots, and his book gives the reader much of the information needed to answer that call.[14]

Philosophical Robotization Literature

The moral and ethical considerations of robots on the battlefield is a topic about which a broad range of literature has been written. Most of the concern comes when discussing the ethics of taking a human out of the loop, and creating an autonomous armed machine. However, there are still moral and ethical implications of remotely-piloted robots as well. Nearly all military robot-related articles and books have at least some component of ethics so this study will touch upon it as well, but only briefly.

[13] P.W. Singer, *Wired for War: The Robotics Revolution and Conflict in the 21st Century* (New York: Penguin Books, 2009), 436.

[14] Paul J. Springer, *Military Robots and Drones: A Reference Handbook* (Santa Barbara, CA: ABC-CLIO, 2013), xii.

M. Shane Riza looks at the ethical consequences of robots on the battlefield, and argues that an increasing use of military robots can lead to an almost nonchalance about warfare, which will increase noncombatant casualties.[15] Ronald Arkin takes a more technical approach, discussing the actual programming that needs to be done to a military robot to give it "an ethical 'conscience.'"[16] Finally, Robert Sparrow offers a good overview of ethical considerations of military robots, trying to take a balanced approach. He does raise the comparison between remotely-operated and fully-autonomous military robots, however, claiming the latter systems have "relatively few precedents in existing weapons."[17]

Closely related to the ethical considerations of robots are the questions of legality. Singer offers a whole chapter that has to do with the legal implications of military robots, such as their right to self-defense, and accountability if a robot makes a mistake. He poses the question that perhaps we need a "revolution in military legal affairs."[18] However, Notre Dame Law professor Mary Ellen O'Connell rebuts Singer in the American Society of International Law *Insights.* She argues that drones are simply another type of battlefield weapon, and that "drones have not created a revolution in legal affairs."[19]

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[15] M. Shane Riza, *Killing Without Heart: Limits on Robotic Warfare in an Age of Persistent Conflict* (Washington, DC: Potomac Books, 2013), 177.

[16] Ronald Arkin, *Governing Lethal Behavior in Autonomous Robots* (New York: Taylor & Francis Group, 2009), 4.

[17] Robert Sparrow, "Robotic Weapons and the Future of War," in *New Wars and New Soldiers: Military Ethics in the Contemporary World*, ed. Paolo Tripodi and Jessica Wolfendale (Burlington, VT: Ashgate Publishing, 2012), 118.

[18] Singer, 407.

[19] Mary Ellen O'Connell, "The International Law of Drones," American Society of International Law *Insights* 14, issue 36, accessed July 23, 2015, https://www.asil.org/insights/volume/14/issue/37/international-law-drones.

Methodology

This paper will use a case study method, but with the addition of a historical comparison. This will serve two purposes. First, the case study allows for a deeper examination of current and near-future doctrine and robotic capabilities. Second, the historical comparison will give an example of similar circumstances that should help the reader understand possible trajectories for robotization of the battlefield.

Using a case study will allow for an in-depth analysis of the technology and the span of its use. These two elements are the key to understanding how the Army incorporates robots into operations, and what robots are currently capable of. The case study will focus on Army and ground-support robots specifically, to keep within a reasonable scope.

The historical comparison with early aviation doctrine serves two purposes. Primarily, it will provide a road map of sorts to better plan for incorporate a new capability into the force. A century ago, Army planners had to determine how best to use their new Sopwith Camels, much like current planners need to do the same with unmanned aerial vehicles (UAVs) and unmanned ground vehicles (UGVs). By studying how the technology was incorporated in the past, one can avoid repeating mistakes. An added benefit of using a historical comparison is that it opens more avenues for further research. Though this study will only touch on one past example, there are a multitude of other possible historical corollaries that can be drawn. Hopefully this will prompt the reader to investigate more.

Historical Case Study: Early Aviation

To begin understanding the current and future operationalization of military robots, it is useful to make a historical comparison. This chapter will examine early aviation doctrine, comparing it to the operational application of airpower. Then, to compare aviation with military robots, the study will determine a specific point when United States military aviation was considered an effective operational tool, and how that point in time related to the theoretical rhetoric.

Early Aviation History

The Wright brothers' first flight on December 17, 1903 heralded a new age in travel, industry, and warfare. The first airplanes were flimsy, held together with wire and cloth. During the age of balloons, the US Army relegated aviation responsibilities to the Signal Corps. By 1907 the Signal Corps solicited bids for military aircraft with the ability to carry two passengers forty miles in an hour.[20]

In the Interwar period the capabilities of military aviation grew exponentially. An average aircraft at the end of World War I (in this instance, a De Havilland D.H.4) had a top speed of 143 miles per hour, and a range of 3.75 hours.[21] By the beginning of World War II many military aircraft could go more than three times that speed. A comparable aircraft (a De Havilland Mosquito) in the beginning of World War II had a top speed of 425 miles per hour and a range of 3,500 miles.[22]

World War II brought a sense of urgency to the development of military aviation. The United States went from slow, ungainly aircraft to incredibly capable bombers and fighters, not to mention a new breed of attack aircraft that changed the operational battlefield. The attack aircraft, fighters, and bombers worked together to create a multidimensional force that played an instrumental role in the Allied victory. Unlike World War I, where aircraft were practically a footnote, without airpower, World War II would have progressed far differently.

During the Cold War, military aviation continued to develop, but there were no breakthroughs like there were during World War II. Capabilities reached a plateau, with only incremental improvements in their effectiveness on the operational battlefield. Using bombers

[20] Rebecca Robbins Raines, *Getting the Message Through: A Branch History of the U.S. Army Signal Corps* (Washington, DC: Center of Military History, 1996), 128.

[21] John W.R. Taylor, ed., *Jane's 100 Significant Aircraft, 1909-1969* (New York: McGraw-Hill, 1969), 36.

[22] Ibid., 102.

with nuclear weapons seems to be a major change, but in reality is not about the aircraft capability but instead about the bomb's capability. Thus, the actual capabilities of military aviation did not change significantly, but one specific facet (nuclear weapons) fundamentally affected not only aviation but warfare itself.

Early Aviation Theorists

In the dawn of the aviation age, theorists looked on aircraft in a number of different ways. For example, some saw them as a weapon to end all war, some thought aircraft would be a non-factor, and some theorists took the middle approach, understanding that airplanes could change, but would not end, warfare. In the United States specifically, theorists can be grouped into two factions: the airplane as a strategic weapon, and the airplane as a ground-support weapon. Both of these groups developed their theories most during the interwar period of the 1920s and 1930s, and both had an effect on the execution of World War II.

Military aviation in World War I changed over the course of the war. Initially aviators had a limited role in the war, as witnessed by a German staff report from October, 1914: "The duty of the aviator is to see and not to fight." [23] Eventually, however, a 1918 German report described the duty of the aviator as "to destroy the enemy over his own ground."[24] Aircraft were used for reconnaissance, then as fighters to destroy the enemy's reconnaissance, and finally as bombers to attack the enemy. Thus, by the end of World War I, airpower was seen as an offensive tool, similar to infantry, artillery, and the also-new tanks.

The bombing efforts of Great War belligerents all evolved in a similar fashion. There were two main focuses for the bombers –bombing to support ground troops, and bombing to affect civilian morale. The former was somewhat effective, especially as aircraft ranges increased

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[23] Quoted in H.E. Hartney, *Air Tactics* (Washington: Government Printing Office, 1920), 3.

[24] Ibid.

and they were able to hit supply depots and other rear areas that artillery could not reach.[25] The latter also became effective during the war, though at a relatively low return on investment. By the end of the war, British strategic bombers required 650 missions to drop less than one ton of bombs per mission average, and killed 729 Germans in the process.[26] Though not stellar in its effectiveness, the British bombing campaign taught lessons to the British military similar to those learned by so many other militaries after the Great War. British military leaders gained an appreciation for strategic bombing, while German leaders dismissed it as ineffective. Additionally, American and Italian theorists also saw the great potential of air power, leading to the rise of four great air power theorists.

The theories of Giulio Douhet provide a foundation for many following airpower theorists. Douhet, an Italian, posited that airpower alone could win a war offensively through strategic bombing. Douhet had practical experience that influenced his theories, and as the Commander of Italy's Air Battalion, he approved construction of the first bombers for the Italian Air Force. Douhet's experience and his theory that aircraft could destroy an enemy's infrastructure and industry within days led to his court-martial and a one-year prison term, which gave him time to work on his theories.[27] Douhet argued that the air force should be its own branch, and the ground forces should defend, to allow time to mass air forces for a victory.[28] Douhet does not argue against having a ground force, and only argued that it needed be just strong enough to defend.

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[25] Walter J. Boyne, *The Influence of Air Power upon History* (Gretna, LA: Pelican Publishing Co., 2003), 92.

[26] Martin van Creveld, *The Age of Airpower* (New York: Public Affairs, 2011), 48.

[27] Boyne, 93.

[28] Giulio Douhet, *The Command of the Air*, trans. Dino Ferrari (Washington: Office of Air Force History, 1983), 255.

Hugh Trenchard provided early direction to British airpower doctrine when Winston Churchill appointed him Chief of the Air Staff in 1919.[29] His ideas were different from Douhet's. While Douhet argued that airpower could be the sole offensive factor in winning a war, Trenchard saw the role of airpower as a supporting arm to ground forces.[30] Eventually Trenchard was influenced by both Douhet and his British military superiors, and during the interwar period he became an advocate for strategic bombing.[31]

Billy Mitchell was the founding member of the American airpower theorist movement. His theories regarding military aviation changed over time and were ultimately influenced by Douhet more than Trenchard. In 1921 he laid out a future for the fledgling air power in *Our Air Force*, as an important piece of any military operation, but not as the single decisive tool that Douhet argued.[32] Mitchell's theories had a strong influence on American doctrine going into World War II, but it would take one more theorist to synthesize Douhet, Trenchard, and Mitchell.

The last important early airpower theorist is one of Mitchell's proteges, Alexander de Seversky. In *Victory Through Air Power* (1942), de Seversky argued that airpower should not be relegated to a tactical role, and should be a strategic arm; however, unlike Douhet and Mitchell, de Seversky argued that friendly airpower should be used to attack the enemy air force directly by gaining air superiority, instead of attacking the enemy's airfields or industrial infrastructure.[33] De

[29] Boyne, 128.

[30] van Creveld, 54.

[31] Azar Gat, *A History of Military Thought from the Enlightenment to the Cold War* (Oxford: Oxford University Press, 2001), 593.

[32] William Mitchell, *Our Air Force: The Keystone of National Defense* (New York: E.P. Dutton & Co., 1921), 15.

[33] Boyne, 354.

Seversky was a second-generation airpower theorist who, though some of his theories were extreme, was able to make airpower theory accessible to the American public.[34]

The Intersection of Theory and Application

To understand the evolution of aviation doctrine and theory, it is necessary to pinpoint the time when doctrine met the expectations of the theorists. This point was during World War II, when the US Army Air Corps became a decisive arm at both the tactical and operational levels, and ultimately had a strategic effect as well. This supports the theories of both Mitchell and de Seversky. Before World War II, airpower was unable to meet the expectations of early theorists. After World War II, airpower theorists primarily refined pre-war theory, due to the overshadowing of conventional military capabilities by the strategic capabilities of nuclear weapons.

The pre-war theories of airpower's effectiveness in both the ground-support and the strategic bombing roles were borne out in World War II. In the ground-support role, aircraft capabilities grew during the war, with aircraft like the P-47 Thunderbolt which was designed as a fighter, but eventually found great success as a fighter-bomber in the European theater.[35] In the Pacific theater, the Navy and Marine Corps made great use of aircraft in a ground-support role. The Marine F-4 Corsair was a versatile land-based fighter-bomber, while the Navy used aircraft like the Douglas Dauntless and Devastator in the dive bomber and torpedo bomber roles, respectively.[36] These aircraft's missions were all similar to those foreseen by Trenchard and Mitchell; they were all either built for or repurposed specifically for their ground-support roles.

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[34] Philip S. Meilinger, *Airmen and Air Theory: A Review of the Sources* (Maxwell Air Force Base, AL: Air University Press, 2001), 129.

[35] Bill Gunston, *The New Illustrated Guide to Allied Fighters of World War II* (New York: SMITHMARK, 1992), 144.

[36] James C. Fahey, *The Ships and Aircraft of the United States Fleet, Victory Edition* (New York: Ships and Aircraft, 1945), 48-9.

Douhet and de Seversky's theories also became reality through the strategic bombing campaigns in both Europe and the Pacific. One of the early goals of operations such as Husky and Avalanche was to gain control of airbases that would allow Allied aircraft to bomb Germany directly.[37] By the end of the war, American and British bombers executed daytime and nighttime bombing missions against Germany, thanks to increased capabilities of the bombers and their fighter escorts, especially the latter's new longer ranges afforded by auxiliary fuel tanks.[38] The fact that Allied leaders both planned operations and focused efforts on designing equipment to facilitate strategic bombing shows the impact of early theories on practice in World War II.

The Point of Effectiveness of Early Military Aviation

To compare early aviation doctrine and theory with current military robot doctrine and theory, it is necessary to pinpoint the time when doctrine met the expectations of the theorists. Just knowing that the planning and execution coincided with theories is not enough; instead, the practice must have been effective to know the apex of aviation theory and practice.

Measures of Effectiveness

The first step in determining effectiveness is to define the term "measures of effectiveness." Measures of effectiveness (MOE) are "used to assess changes in system behavior, capability, or operational environment .. [and are] tied to measuring the attainment of an end state, achievement of an objective, or creation of an effect."[39]

The MOE for airpower in World War II, particularly in the ground support role, is the effect that it had on the enemy's ability to fight. This can be measured in several ways. The first

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[37] Kenneth V. Smith, *Naples-Foggia: The U.S. Army Campaigns of World War II* (Fort McNair, DC: U.S. Army Center of Military History), 4.

[38] Richard Overy, *Why the Allies Won* (New York: W.W. Norton & Company, 1995), 123.

[39] Joint Publication (JP) 3-0, *Joint Operations* (Washington, DC: Government Printing Office, 2011), GL-13.

way to examine the MOE of airpower is by comparing enemy equipment or troops destroyed with the number of aircraft needed to do it. One of the greatest examples of airpower's supremacy in naval warfare was the attack by carrier-based aircraft against the Japanese battleship *Yamato* in April 1945. *Yamato* was the most heavily armored ship in history, with nearly 23,000 tons of armor plating protecting it.[40] During the American assault on Okinawa, US carrier-based aircraft attacked the ship, sinking it after three large waves of bombers and torpedo planes attacked within two hours. The Americans lost a small number of aircraft, including a few that were destroyed by the explosion that engulfed the ship as it broke apart and sank.[41] The sinking of the *Yamato* was a practical, wartime application of Billy Mitchell's theories from two dozen years earlier.

The second way to determine the MOE of airpower in World War II, specifically in the strategic bombing role, is through its effects on the enemy populations and on German and Japanese industrial production. The effects in the Pacific and European theaters were similar, and the United States Strategic Bombing Survey analyzed these effects beginning in 1944. Over one thousand military and civilian personnel scoured intelligence and statistical material in Germany and Japan during and after the war, creating over two hundred reports to document the effects of strategic bombing.[42]

The bombing campaign against Germany had an impact on the civilian population that the survey team found by interviewing community leaders, through questionnaires submitted by people who escaped Germany, and via captured German civilian mail.[43] A March 1944 German

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[40] Janusz Skulski, *The Battleship Yamamoto* (Annapolis, MD: Naval Institute Press, 1988), 15.

[41] Skulski, 12.

[42] Franklin D'Olier, *The United States Strategic Bombing Survey Over-all Report (European War)* (Washington, DC: Government Printing Office, 1945), IX. Due to its proximity to the ongoing fighting, the results of the survey are not unquestionably objective. However, the numbers provided in the survey still show an understanding and measurement of the effectiveness of the strategic bombing campaign.

[43] D'Olier, 95.

report quoted in the survey said "'One can even hear from trustworthy citizens that one ought to make an end of the war, for it cannot be worse than it is now.'"[44] However, the repressive German government was able to keep the citizens from revolting, and ultimately the population continued unwillingly fighting.[45]

In Japan the civilian population was almost uniformly affected by strategic bombing, with those persons displaced from targeted cities bringing their low morale to rural areas as well, with sixty-four percent having reached a point where they felt they could no longer support the war. The majority of the people lost their will as a result of air attacks.[46]

The Plateau of Military Aviation After World War II

After the war, military aviation reached a plateau where there was no longer major innovation, and theories were mostly evolutionary rather than revolutionary. In some ways the advent of nuclear weapons made airpower irrelevant – missiles could be launched from submarines and land-based silos just as easily as they could from aircraft. The greatest change in airpower was the creation of the United States Air Force in 1947.[47] In the conventional wars following World War II, airpower served the same ground support role as it did during the latter war, but has not performed the strategic bombing role since 1945.

The Korean War was the Air Force's first opportunity to act as a separate branch, and they worked well with ground forces, playing a decisive role in defeating the Communist offensives of late 1950 and early 1951.[48] In the Vietnam War, the Air Force conducted the ground

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[44] D'Olier, 97.

[45] Ibid., 99.

[46] Franklin D'Olier, *The United States Strategic Bombing Survey Summary Report (Pacific War)* (1946; repr., Maxwell Air Force Base, AL: Air University Press, 1987), 95. See comment on objectivity in footnote 23.

[47] National Security Act of 1947, Public Law 253, (July 26, 1947), §208.

[48] Matthew B. Ridgway, *The Korean War* (New York: Da Capo, 1967), 244.

support role and tried to execute strategic bombing missions; however, due to restrictions of the Cold War, the United States was unable to apply enough pressure to the North Vietnamese people and government to staunch their war effort.

The late Cold War, the Modern Interwar Period, and the Global War on Terror period were similar with regards to military aviation. The basic roles and missions of the Air Force remained the same as they were in 1947. The Goldwater-Nichols Act codified the need for jointness among the services, showing that airpower was just one tool in the American military kitbag. Airpower had a dominant role in the opening stages of Operation Desert Storm, but it was primarily to support the invasion by ground forces less than four days later. American airstrikes in Bosnia sparked a brief renaissance of the concept of airpower acting alone, but it never escaped the theoretical stage.[49] Airpower is now what it was sixty years ago – an element of American military power to be used in conjunction with all the other elements.

Acceptance of Military Aviation

Military aviation became an accepted part of the United States military during the interwar period, and an integral part of operational and strategic planning by the end of World War II. This acceptance was from two important parties – the American public and the rest of the military establishment.

Public Perceptions of Military Aviation

One driving factor when measuring the effectiveness of military aviation, especially in the United States, is when the American public saw aircraft and airpower as viable military tools. The fascination with aviation began immediately, and blossomed with the introduction of World War I aviation movies in the early 1930s. The appearance of the term "aviator" in English-language books published in the United States grew seven-fold between 1900 and 1920,

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[49] Benjamin S. Lambeth, *NATO's Air War for Kosovo: A Strategic and Operational Assessment* (Santa Monica: RAND Corporation, 2001), 250.

remaining at the same level until 1950 when it dropped by more than 50%.[50] This growing public fascination with military aviation merged with the propaganda films of World War II, culminating with Walt Disney's *Victory Through Air Power*, based on de Seversky's book. After World War II, the number of combat aviation films dwindled, with some notable exceptions. This was due in part to the plateauing of military aviation's capabilities, along with a dearth of large-scale conflicts in which military aviators could display their contributions to the fight. The heyday for military aviation movies, then, was between 1930 and 1945.

Establishment Acceptance of Military Aviation

The other group that needed to accept military aviation was the rest of the military establishment. This acceptance happened along the same time frame as public acceptance, but was really cemented during the first couple of years of World War II. General Dwight Eisenhower argued that American success in World War II depended on airpower. In his memoirs he claimed that the greatest learned lesson from the war "was the extraordinary and growing influence of the airplane" and that "its effect … was decisively felt on both fronts, the Allied and the Russian."[51] Generals Patton, Marshall, and Bradley all valued airpower as a vital part of their military experience, from the tactical level through the strategic level of the war.[52]

Congressional Emphasis on Military Aviation

The final group that needed to accept military aviation as an undeniable part of future warfare was Congress. During his time as the Assistant Chief of the Air Corps, Billy Mitchell was outspoken and vocal about the need for a separate air arm of the military. However, the Chief of the Air Corps, Mason Patrick, was the one who was able to convince Congress to pass the Air

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[50] Alan J. Vick, *Proclaiming Airpower: Air Force Narratives and American Public Opinion from 1917 to 2014* (Santa Monica, CA: RAND Corporation, 2015), 26.

[51] Dwight D. Eisenhower, *Crusade in Europe* (New York: Doubleday, 1948), 452.

[52] Jeffery R. Barnett, "Great Soldiers on Airpower," *Airpower Journal* Volume XII, no. 4 (Winter 1998): 17-28.

Corps Act of 1926, which provided the foundation on which the fledgling service was built.[53] The Air Corps Act created a position for Assistant Secretary of War for Air, and set the size of the Air Corps to 20,000 men and 1,800 aircraft.[54] This Congressional support was vital to ensure the rise of airpower.

Ethical Considerations of Military Aviation

World War I brought with it a new era of weaponry, the likes of which had not been used on such a scale as it was during the war. The airplane was one of these new weapons, and there was much debate about how to use it while still staying within the accepted ethical boundaries of warfare. This was the focus of airpower theorists throughout the interwar period

The ethical issues surrounding airpower in its infancy became less important than the practical and strategic considerations of how to employ air weapons in World War II. In 1939, President Franklin Roosevelt appealed to the Soviets to stop "ruthless bombing from the air of civilians in unfortified centers of population" and that if this type of warfare became the norm, "hundreds of thousands of innocent human beings who are not even remotely participating in hostilities, will lose their lives."[55]

Roosevelt's prophecy became truth after he accepted bombing civilian population as part of the war. In his State of the Union Address of 1942, Roosevelt assured the American people that the war was down to mathematical factors, and this fact "would become evident to the Japanese people themselves when we strike at their home islands, and bomb them constantly

[53] Philip S. Meilinger, *Airmen and Air Theory: A Review of the Sources* (Maxwell Air Force Base, AL: Air University Press, 2001), 6.

[54] Mark A. Clodfelter, "Molding Airpower Convictions: Development and Legacy of William Mitchell's Strategic Thought," in *The Paths of Heaven: The Evolution of Airpower Theory*, ed. Phillip S. Meilinger (Maxwell Air Force Base, AL: Air University Press, 1997), 105.

[55] Franklin D. Roosevelt, "The President Appeals to Russia and Finland to Desist from Bombing of Civilians. December 1, 1939," in *The Public Papers and Addresses of Franklin D. Roosevelt. 1939 Volume, War and Neutrality* (New York: MacMillan, 1941), 588.

from the air."[56] By the end of World War II, US bombers killed almost 400,000 Japanese civilians, over half of whom were killed in either Hiroshima or Nagasaki.[57]

The ethical considerations of bombing civilians were an abstraction for Roosevelt before the US entered the war. However, when the choice came to American losses or enemy losses, it was no longer hypothetical, and strategic bombing became a logical, albeit pragmatic, solution.

Industrial Production Capacity Meets Demand

The apex of military aviation came about when the industrial capacity to produce aircraft met the demand from the military and others to use that airpower. This was only possible when the inevitability of America's entrance into World War II forced the government to focus on increasing capabilities and technologies.

Before the United States became directly involved in the war, the Americans produced arms and equipment and aircraft for not only their own army, but they also sold these things to the British as well. In 1941, Henry Ford turned his industrial might toward aircraft production, and by the time the Japanese attacked Pearl Harbor, he was already building B-24 bombers.[58] Once Roosevelt won his second reelection, he encouraged others to follow Ford's lead. Aircraft production doubled between 1941 and 1944, and in those four years United States factories built 297,000 aircraft, at a rate double the German and quadruple the Japanese production capacities.[59] The US industrial complex was clearly capable of out-producing its enemies, and this ability drove the growth and acceptance of military aviation.

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[56] Franklin D. Roosevelt, "'The Spirit of This Nation Is Strong—The Faith of This Nation Is Eternal'—Address to the Congress on the State of the Union. January 7, 1943," in *The Public Papers and Addresses of Franklin D. Roosevelt. 1943 Volume, The Tide Turns* (New York: Harper, 1950), 23.

[57] John W. Dower, *War Without Mercy: Race & Power in the Pacific War* (New York: Pantheon Books, 1986), 298.

[58] David M. Kennedy, *Freedom From Fear: The American People in Depression and War, 1929-1945* (New York: Oxford University Press, 2005), 653.

[59] Overy, 191-97.

Conclusions

When studying the evolution of military aviation, one can see a distinct era when its capabilities met the expectations of airpower theorists. At the same time, a need arose for military aviation to support land and naval forces. Between 1940 and 1945, all of these factors combined to make military aviation a necessary factor on the World War II battlefield. The theories devised by Douhet, Trenchard, Mitchell, and de Seversky came to fruition in the execution by the Allied air forces in both the European and Pacific theaters. The industrial capacity to build aircraft, Congressional support to procure aircraft, public fascination with airpower, and ground force acceptance of airpower converged in World War II – the apex of airpower.

Modern Case Study: Military Robots

Now that this author has established a historical baseline with which to compare military robots, one must use the same measures to look at contemporary military robots.

Robot History

The word 'robot' can be traced to 1920 when Karel Čapek used it in his play *Rossum's Universal Robots*.[60] The word robot is defined as "A machine capable of carrying out a complex series of actions automatically, especially one programmable by a computer" but for the purpose of this study, military robots will include both autonomous and remotely operated machines.[61] This keeps the focus of the case study broad enough to compare with the historical case study, while also minimizing the deep philosophical issues that are an essential part of autonomous military robot use.

Military robots are merely extensions of the evolutions of their manned predecessors. For instance, remotely piloted aircraft are simply aircraft. Therefore, to study the evolution of robots,

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[60] Oxford English Dictionary, 'robot'.

[61] The use of autonomous military robots is a subject worth much more study; however, the operational implications of autonomous military vehicles are currently overshadowed by the strategic and ethical considerations.

one must understand the evolution of military vehicles in general. Since the introduction of internal combustion engines to the battlefield, military vehicles have evolved with a few key factors in mind. First, they must be effective at their task, whether it be transporting, reconnoitering, killing, or any other task. Over the past hundred years, vehicles have been tailor-made to accomplish separate tasks, with some attempts at creating multi-purpose vehicles. For example, a D9 bulldozer has a very specific task as a construction vehicle, whereas the HMMWV can be repurposed to multiple tasks.

Second, military vehicles must integrate with the rest of the 'system' that they are joining, whether it is an infantry battalion, a carrier strike group, or a long-range bomber squadron. For example, the EA6B Prowler aircraft had a very specific role that fits in an airstrike package that included multiple other vehicles and systems.[62] A military robot must fulfill both of these factors – it needs to be effective at its task, and it must integrate with the overall military system.

Both the Germans and Soviets used military robots in World War II. The former focused on smaller, wire-controlled vehicles that carried explosives, while the latter created a full-size, radio-controlled tank. Neither of these vehicles had a remarkable effect on the outcome of the war, with the smaller vehicle too slow for the battlefield and the larger vehicle having poor controls and no doctrine guiding its deployment.[63] The Germans had better success in the air with their V-1 flying bomb. They launched over 8,000 V-1s against the United Kingdom, killing an average of 1.3 Britons per $900 missile.[64]

[62] John Trotti, *Marine Air* (Novato, CA: Presidio Press, 1985), 60.

[63] Paul J. Springer, *Military Robots and Drones: A Reference Handbook* (Santa Barbara, CA: ABC-CLIO, 2013), 11.

[64] van Creveld, 227.

The American response to the effectiveness and ubiquity of German V-1s was to dramatically increase funding, manning, and support for military research and development.[65] Part of the research was targeted toward creating military robots that were used for reconnaissance in the Vietnam War, as instrument and system test-beds during the Space Race, and as the descendants of the V-1, modern-day cruise missiles. After witnessing the capabilities of Soviet air defense systems during the Arab-Israeli conflicts, the United States shifted its interest to unmanned aerial vehicles that could deliver a payload without risking a pilot's life. In 1971, a Teledyne Ryan Model 234 Remotely Piloted Vehicle air-launched from a DC-130 flew at 1,000 feet towards a simulated anti-aircraft radar vehicle, launched a Maverick air-to-ground missile, and destroyed the vehicle.[66]

By the mid-1990s military robots began to generally resemble what they are today. Ground vehicles like the PackBot and the Talon provided support with reconnaissance and remote viewing capabilities similar to contemporary explosive ordnance disposal robots.[67] The Predator robot that flies over Afghanistan and Iraq today began its service in 1994.[68] Therefore, we are currently in the mature stage of military robot development, and should only expect incremental changes in the capabilities of military robots in the future.[69]

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[65] Richard P. Hallion, "U.S. Air Power," in *Global Air Power*, ed. John Andreas Olsen (Washington, D.C.: Potomac Books, Inc., 2011), 84.

[66] Michael Armitage, *Unmanned Aircraft* (London: Brassey's Defence Publishers, 1988), 80-81.

[67] Singer, 22-26.

[68] Springer, 22.

[69] The one monumental change remaining is full autonomy, to be discussed in the last chapter of this monograph. This is not so much a change in the capabilities or design of military robots, but is instead a change in the perception and consideration of the second-order effects of using autonomous military robots.

Returning to the original two factors to consider when analyzing military robots, one can see their development as a logical trajectory. Military robots are designed for very specific tasks, and perform those tasks admirably. The Predator is an excellent reconnaissance aircraft, and the Talon is a great ordnance disposal platform. The former was developed through the same processes as its manned cousins. The aerodynamics, structure, and other systems were created with airworthiness and efficiency in mind, but without having to consider life support systems. The latter, however, was a new type of military vehicle, without a manned precedent. The Talon has some characteristics of a tank, but is clearly not a tank. Its development was more a matter of taking components that were at hand in the shop where it was designed, including treads from a snowmobile and night vision goggles made for humans.[70]

Though they are great at their initially intended tasks, both the Predator and the Talon have found new roles on the battlefield. Using a historical example, the UH-1 Iroquois (Huey) transport helicopter evolved into the UH-1C gunship helicopter, which then prompted development of the AH-1 Cobra attack helicopter.[71] Similarly, the RQ-1 Predator, originally built for reconnaissance, was armed with Hellfire missiles in 2001, becoming the MQ-1. The MQ-9 Reaper, which is able to carry a greater load and more weapons, supplanted the Predator as the unmanned weapons-delivery platform of choice.[72]

The Talon, on the other hand, was made into an armed version in much the same way as it was designed in the first place, even to the backronym used as its name. The Special Weapons Observation Reconnaissance Detection System (SWORDS) is a Talon chassis with some modifications. Its builders attached a gun to the robot in lieu of its EOD-focused arm. High-

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[70] Singer, 27.

[71] James W. Bradin, *From Hot Air to Hellfire: The History of Army Attack Aviation* (Novato, CA: Presidio Press, 1994) 114-120.

[72] Springer, 22-23.

resolution night vision-capable cameras complement the gun to give the robot sniper-like precision, whether it has a machine gun or a sniper rifle mounted.[73] Thus, the Talon has evolved from a mission of manual interaction with explosives to one of battlefield control via long-range direct fire or automatic suppressive fire. These military robots have transitioned from focus on a single capability to become multi-capable machines.

Military robots are also integrated with other military systems on the battlefield. Ground and air robots interface with other weapons platforms through standardized communications, regulations that dictate use, and a common understanding of capabilities that supports an informal set of tactics, techniques, and procedures (TTPs).

This study will concentrate on ground and air military robots. UAVs are clearly in the majority of military robots, and ground robots have a direct impact on operational planning, while naval robots are only tangentially related to Army operations. Additionally, the United States Navy had no operational unmanned surface vehicles in 2013, and have only three such systems in production.[74] The Association for Unmanned Vehicle Systems International (AUVSI) lists over 2,400 air platforms, but only 880 ground and 810 naval platforms in its database.[75] Therefore, the focus will remain heavily on flying robots, and will only occasionally consider ground robots.

Military Robot Theorists

The theory of military robots has its origin in science fiction. Some of the greatest authors of the genre have written about military robots, and though they were not writing military theory per se, their ideas still affected the trajectory of how the military uses robots today. Some of the

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[73] Singer, 30.

[74] Scott Savitz, et al., *U.S. Navy Employment Options for Unmanned Surface Vehicles (USVs)* (Santa Monica, CA: RAND Corporation, 2013), 2.

[75] "Home – Unmanned Systems and Robotics Database," Association for Unmanned Vehicle Systems International, (2015), accessed December 21, 2015, http://roboticsdatabase.auvsi.org/home

better-known science fiction authors who used military robots in their stories are Isaac Asimov, Robert Heinlein, and Ray Bradbury. Military robots have also played a large role in science fiction movies and television shows such as *Star Wars*, *Terminator*, and *The Avengers*.

All of these fictional stories have a common thread in that they portray military robots as working seamlessly and being accepted by other participants in the various battles in which they are involved. This is an important aspect of science fiction as theory, because it plays to the idea that military robots must be fully integrated into the force. Another common thread is that the robots have very low maintenance needs. Thus, the "theory" of military robots that one can gain from science fiction is that they need to become pervasive and low-effort.

More traditionally, military robots have been the subject of numerous debates concerning their relevance and utility on the battlefield. In the 1990s, the United States Air Force directed a series of reports into the use of unmanned aerial vehicles.[76] The *Role of Unmanned Aerial Vehicles in Future Armed Conflict Scenarios* was published in 1994 as a command-sponsored research paper. The author recommended that the Air Force increase budget priority for UAVs, revise doctrine, relook future scenarios while factoring in UAV use, and ensure joint interoperability of UAVs. The author also made note of some of the friction facing the Air Force's acceptance of UAVs in the mid-1990s. Among the friction points were the conflict between senior-level experience in manned platforms, and a misunderstanding of the capabilities of UAVs, both of which could be alleviated by more education and funding.[77]

The 1996 *Report on UAV Technologies and Combat Operations* made a few observations on what was then a new weapon for the Air Force. A key need identified by the Air Force

[76] Some reports refer to them as "uninhabited aerial vehicles" but in this paper the more conventional "unmanned" term will apply.

[77] Dana A. Longino, *Research Report No. AU-ARI-92-12, Role of Unmanned Aerial Vehicles in Future Armed Conflict Scenarios* (Maxwell Air Force Base, AL: Air University Press, 1994), 31.

Scientific Advisory Board was to better integrate the automated and human systems. They saw UAVs as being far more economical than manned platforms for providing surveillance and observation capabilities. They also determined that UAVs could be "weaponized in the near term" which they identified as before 2005.[78] The research team also recommended some missions that could be tasked to UAVs, including suppression of enemy air defenses; fixed target attack; and intelligence, surveillance, and reconnaissance (ISR).[79]

Another study, published in 2000, is *Unmanned Aerial Vehicles: Implications for Military Operations*. This short occasional paper printed by the Air University examines the role of UAVs in the Air Force, comparing and contrasting them to conventional aircraft. The author, Lieutenant Colonel David Glade, argues that UAVs are not ready to take on many of the missions that piloted aircraft perform, and the sensor technology was not at the level needed to make them effective enough. Glade, a pilot himself, implores the reader beware of "a situation in which an autonomous vehicle … mistakenly attacks a school bus … filled with children."[80] Though this possibility is not inconceivable, its inclusion is clearly an appeal to emotion, and actually weakens Glade's theory on UAVs.

The Air Force was not the only source of UAV theories. *Aviation Week and Space Technology* (*AW&ST*) also provided predictions about the future roles of UAVs, with a number of articles appearing in late 1991 after Desert Storm. Some of the theories put forth by *AW&ST* contributors include a future ability for UAVs to provide battlefield commanders with "real-time, all-weather, photo-like imagery" that would replace the need for expensive reconnaissance

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[78] Peter R. Worch, et al., *United States Air Force Scientific Advisory Board Report on UAV Technologies and Combat Operations* (Washington, DC: Department of the Air Force, 1996), vii.

[79] Worch, viii.

[80] David Glade, *Unmanned Aerial Vehicles: Implications for Military Operations* (Maxwell Air Force Base, AL: Air University, 2000), 23.

aircraft like the Lockheed TR-1.[81] Another article discussed the level of control for the Navy's burgeoning UAV capability, arguing the merits of keeping it at the battlegroup level versus the level of Central Command.[82]

The Intersection of Theory and Application

Because military robots are relatively new to the battlefield, and due to the increasing pace of technological advancement, some of the theories from two decades ago have been fully realized.[83] Ultimately the theoretical uses of UAVs can be distilled to two basic missions: UAVs would offer real-time ISR capabilities, and UAVs would provide offensive capabilities to the commander. The first of these became a standard UAV mission by 1995, when the Air Force used Predators to conduct reconnaissance missions over Bosnia, providing live video of Sarajevo to high-level operations centers in Vicenza and Naples.[84]

Not long after their introduction as ISR platforms, military robots were weaponized and used as long-distance killing machines. In October 2001, a Predator fired a Hellfire missile and killed a number of terrorists in Afghanistan.[85] The missile launch was controversial, and brought to light one of the issues discussed in the *AW&ST* article ten years before, due to confusion over

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[81] William B. Scott, "Miniature SAR Systems Mounted on Unmanned Vehicles Offer Battlefield Commanders Real-Time Imagery," *Aviation Week & Space Technology*, December 9, 1991, 44.

[82] "Medium-Range UAV to Help Military Narrow Tactical Intelligence Gap," *Aviation Week & Space Technology*, December 9, 1991, 43.

[83] Technology has advanced exponentially compared to the pace of advancement in the mid-twentieth century. Moore's Law is a good visualization of this idea – computing power doubles while the cost per unit halves every 18 months. This law can be applied to any technological advance, which explains the rapid increase in UAV capabilities in the past twenty years.

[84] Richard Whittle, *Predator: The Secret Origins of the Drone Revolution* (New York: Henry Holt and Company, 2014), 104.

[85] Whittle, 259.

who authorized the launch – the Central Intelligence Agency or the Central Command.[86] By the opening stages of Operation Iraqi Freedom in 2003, the Predator was a common fixture on the battlefield.

Not all theories have borne fruit, however. So far, a UAV has not been involved in a mistaken attack on a school bus.[87] The problem with a lack of education has manifested itself not in the manner initially proposed by the 1994 Air Force research paper, but in a slightly different manner. Commanders have become accustomed to having feeds from UAVs available whenever they need them; however, some commanders have not been educated on the most efficient way to use those feeds. Whereas the original theory was that there was a lack of acceptance due to uneducated leaders, it has instead become acceptance, but with a misuse due to uneducated leaders. For example, a recent member of the Brigade Command Training Program related a story of a brigade command team focused on a feed from a UAV instead of tracking and guiding the overall battle in which they were involved. This misuse of provided assets was quickly corrected.[88]

The Point of Effectiveness of Military Robots

Now this author will determine the time when military robots were able to meet the expectations of their theoretical use, and when military robots became effective participants on the battlefield. Due to their relative recency on the battlefield, few studies examine the effectiveness of military robots.

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[86] Whittle, 260.

[87] There have been collateral casualties, but nothing so dire as an autonomous UAV killing dozens of schoolchildren.

[88] Paul Schlimm, "Experience as a BCTP trainer" (lecture, School of Advanced Military Studies, Fort Leavenworth, 2015).

Measures of Effectiveness

The first step in determining effectiveness is to define the measures of effectiveness and measures of performance. For military robots, the MOE will be similar to those of World War II aviation, but not identical. One of the measures used in World War II was the effect on the enemy population's willingness to fight. This MOE is slightly different when applied to UAVs in the current operating environment, in that the desired effect is to avoid encouraging the civilian population to fight. The other half of the strategic bombing MOE from World War II was the effect on enemy industry. Again, due to the dissimilarities between World War II and the Global War on Terror, this is not strictly an apples-to-apples comparison.

Based on several measurements, UAVs have been effective in Afghanistan and Pakistan. As mentioned, one factor to consider is the public reception and perception of drone strikes. A 2013 study of UAV strikes in Afghanistan and Pakistan found that there was no correlating pattern between civilian casualties and an increased popular turn to violence to support the insurgents.[89] Since drone strikes are more surgical than the strategic bombing campaigns in World War II, the United States is able to better control the effects on the population. In a counterinsurgency, this allows for what Stathis Kalyvas refers to as "selective violence."[90]

The other factor to use as a MOE is the impact that military robots have on the enemy's ability to fight. This includes the effects of attacks against the enemy, as well as negating the enemy's attacks on friendly forces. The former was the topic of a 2001 study that found drone

[89] James Igoe Walsh, *The Effectiveness of Drone Strikes in Counterinsurgency and Counterterrorism Campaigns* (Carlisle Barracks, PA: United States Army War College Press, 2013), 32.

[90] Stathis N. Kalyvas, *The Logic of Violence in Civil War* (New York: Cambridge University Press, 2006), chap. 7.

strikes to have "no significant impact … on Taliban and Al-Qaeda attacks in Afghanistan, but that there is a significant impact … on Taliban and Al-Qaeda attacks in Pakistan."[91]

Acceptance of Military Robots

Since the beginning of the Global War on Terror, UAVs and other military robots have become an accepted part of the American military landscape. The public sees military robots as a normal part of military operations. The rest of the military understands the advantages of using military robots. The acceptance of both of these groups is vital to the future of military robots.

Public Perceptions of Military Robots

Much like early aviation, military robots have kept the American public's fascination since they became part of the military landscape. Robots have played a part in movies, video games, and television shows. Military robots were important in the movies *The Hurt Locker*, *Captain Phillips*, and *Interstellar*.[92] The ethical and operational issues surrounding the use of military robots was most recently highlighted in the British film *Eye in the Sky*, released in early 2016. The film focuses on one specific drone strike, weighing potential civilian casualties against the military benefits of the attack.[93]

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[91] David A. Jaeger and Zahra Siddique, *Are Drone Strikes Effective in Afghanistan and Pakistan? On the Dynamics of Violence Between the United States and the Taliban* (Bonn: Institute for the Study of Labor, 2011), 2.

[92] Bob Fowler, "Robot made by Clinton firm in Oscar winner 'The Hurt Locker,'" *Knoxville News Sentinel*, March 10, 2010, accessed December 17, 2015, http://www.knoxnews.com/business/robot-made-by-clinton-firm-in-oscar-winner-the-hurt-locker-ep-408869009-358870771.html - an explosive ordnance disposal robot features heavily in the opening scene of this contemporary war movie; Gary Robbins, "Spy drone subtly stars in 'Captain Phillips,'" *San Diego Union-Tribune*, October 22, 2013, accessed December 17, 2015, http://www.sandiegouniontribune.com/news/2013/oct/22/scaneagle-navy/ - A US Navy reconnaissance drone was used to investigate the life raft holding the eponymous Captain and his captors in this movie based on a trues story; Mini Anthikad-Chhibber, "Reaching for the stars,'" *The Hindu*, November 9, 2014, accessed December 17, 2015, http://www.thehindu.com/todays-paper/tp-national/tp-karnataka/reaching-for-the-stars/article6579515.ece - An Indian Air Force UAV was used in the beginning of the movie to show the advances that had been made in military technology by the time of this near-term science fiction movie.

[93] "Eye in the Sky: Watch the UK trailer for the drone warfare drama starring Helen Mirren and Alan Rickman – video," *The Guardian*, December 9, 2015, accessed December 17,

Military robots have developed a number of detractors. The ethical issues associated with autonomous military robots raise concerns for not just the general public, but also scientists and futurists.[94] Additionally, the ability for the government to send drone strikes with little to no oversight has raised concerns among the people. Finally, the American public is concerned with a lack of oversight on how many drone strikes have happened, and what the collateral damage might have been.

Establishment Acceptance of Military Robots

Military robots have become an accepted part of the military landscape. They have been the topic of countless articles in military professional journals. They are the focus of RAND studies, SAMS monographs, and planning conferences.

Congressional Emphasis on Military Robots

In 2000, Congress passed the Floyd D. Spence National Defense Authorization Act for Fiscal Year 2001, a plan for not only FY2001, but also the future of military robots. In the wording of the act is specific guidance for development of unmanned aircraft and ground vehicles:

> SEC. 220. UNMANNED ADVANCED CAPABILITY COMBAT AIRCRAFT AND GROUND COMBAT VEHICLES.
> (a) Goal.--It shall be a goal of the Armed Forces to achieve the fielding of unmanned, remotely controlled technology such that--
> (1) by 2010, one-third of the aircraft in the operational deep strike force aircraft fleet are unmanned; and
> (2) by 2015, one-third of the operational ground combat vehicles are unmanned.[95]

2015, http://www.theguardian.com/film/video/2015/dec/09/eye-in-the-sky-watch-the-uk-trailer-for-the-drone-warfare-drama-starring-helen-mirren-and-alan-rickman-video

[94] "Autonomous Weapons: An Open Letter From AI & Robotics Researchers," Future of Life Institute, (July 28, 2015), accessed August 20, 2015, http://futureoflife.org/open-letter-autonomous-weapons/

[95] Floyd D. Spence National Defense Authorization Act for Fiscal Year 2001, Public Law 106-398, (October 30, 2000), §220.

The Spence National Defense Authorization Act was perhaps too optimistic in its timeline, but it set the precedent that unmanned systems would be a priority for military spending. Less than a year after the law was passed, however, funding for the Global War on Terror replaced spending on military robots.

The John Warner National Defense Authorization Act for Fiscal Year 2007 renewed Congressional support for military robot programs. This law dictated that the Department of Defense give priority to unmanned systems:

> SEC. 941. DEPARTMENT OF DEFENSE POLICY ON UNMANNED SYSTEMS.
> (a) Policy Required.--The Secretary of Defense shall develop a policy, to be applicable throughout the Department of Defense, on research, development, test and evaluation, procurement, and operation of unmanned systems.
> (b) Elements.--The policy required by subsection (a) shall include or address the following:
> (1) An identification of missions and mission requirements, mission requirements for the military departments and joint mission requirements, for which unmanned systems may replace manned systems.
> (2) A preference for unmanned systems in acquisition programs for new systems, including a requirement under any such program for the development of a manned system for a certification that an unmanned system is incapable of meeting program requirements.[96]

The 2007 authorization clearly shows the priority that military robots have in the future of the military.

Ethical Considerations of Military Robots

The use of military robots raise some of the same ethical deliberations as early airpower theorists raised when examining strategic bombing. However, there are far deeper ethical issues when arming robots, which this paper will discuss only as they compare with the same considerations in the historical case study.

In World War II, pragmatism overcame ethical concerns as Roosevelt flipped from condemning attacks against civilians to condoning them. In the realm of military robots, the

[96] John Warner National Defense Authorization Act for Fiscal Year 2007, Public Law 109-364, (October 17, 2006), §941.

weaponization of robots has become a de facto part of warfare. However, there are still ethical qualms about armed Predators, Talons with machine guns, and other systems. In the Global War on Terror, the US public is far enough removed and the casualties are low enough that there is not as much incentive to use robots to protect military members' lives.

Industrial Production Capacity Meets Demand

Military robots have become cheaper and easier to build in the past twenty years. The RQ-1 Predator, for example, cost $13 million ($20 million in 2016 dollars) per aircraft in 1998, or $53 million per system, with each system including four aircraft and their ground equipment.[97] The FY2016 budget for the Air Force has a total cost of $627 million for 33 MQ-9 Reaper aircraft, or $19 million per system, with each system including an aircraft and all the ground support equipment.[98] The Reaper is more capable, has better sensors, and carries a greater payload than the Predator, and is cheaper per aircraft in common-year dollars. This trend will continue as technology becomes cheaper.

The ability for manufacturers to produce military robots has increased dramatically and is forecasted to continue growing worldwide. The Teal Group analyzes defense and aviation industry spending for investors, government officials, and other professionals in the field.[99] They estimate that civil and military UAV production will grow from $4 billion annually to $13 billion

[97] United States Air Force, *Committee Staff Procurement Backup Book, FY1999 Budget Request*, Secretary of the Air Force Financial Management and Budget Office, (Washington, DC, February 24, 1998).

[98] United States Department of Defense, *Department of Defense Fiscal Year (FY) 2017 President's Budget Submission, Aircraft Procurement, Air Force, Vol-1*, Secretary of the Air Force Financial Management and Budget Office, (Washington, DC, February 2016).

[99] "About Teal Group Corporation," The Teal Group, 2016, accessed February 20, 2016, http://www.tealgroup.com/index.php/about-teal-group-corporation.

annually in the next ten years. Additionally, spending on military UAV research will add $30 over that same time period.[100]

Analysis: Military Robots at the Decisive Point

Military robots are currently at the decisive point in their history. Like airpower during World War II, military robots are effective, accepted, meet theoretical expectations, and are in demand consummate with the ability for industry to provide them.

Military Robots are Effective

During World War II, military aviation reached a point where it was an effective tool at both the operational and strategic levels. Since 2005, military robots have also reached that point. Like mid-twentieth-century military aviation, military robots are effective at the tactical, operational, and strategic levels of war. Aircraft like the P-47 Thunderbolt and the F4-U Corsair provided tactical air support to soldiers and Marines. The Army uses the Talon robot for explosive ordnance disposal duties. In World War II, C-47 aircraft allowed paratroopers to be dropped in support of large-scale operations like the invasions of Sicily and Normandy. Today, Predators allow operational-level commanders to see different parts of the entire theater from their command post. Finally, the strategic bombing campaigns against Germany and Japan helped affect the Axis populations, climaxing with the two atomic bombs dropped on Japan. Throughout the Global War on Terror, military robots have been used to kill top leaders of the Taliban, al-Qaeda, and ISIL.

Military Robots are Accepted

Military aviation was first accepted as a contributing member to military operations in World War I. By World War II, military aviation became a vital part of operational and strategic planning, and was ultimately the military arm of decision in the Pacific theater. Additionally, the

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[100] "UAV Production Will Total $93 Billion," The Teal Group, August 17, 2015, accessed February 20, 2016, http://www.tealgroup.com/index.php/about-teal-group-corporation/press-releases/121-uav-production-will-total-93-billion.

American public accepted military aviation as an important part of the United States military during World War II.

Military robots have reached the same point over the past ten years as military aviation reached during World War II. Leaders at all levels not only accept military robots, but many depend on military robots to make decisions on the battlefield. Tactical commanders rely on remotely-piloted vehicles to clear improvised explosive devices along their routes. Strategic commanders depend on military robots to attack targets that might otherwise be unreachable by conventional means. Most importantly, operational leaders have become accustomed to being able to see any part of their area of operations from within their own operations center. These things are a part of the modern battlefield and they all depend on military robots.

Military Robots are Meeting Expectations

The use of military aviation finally coincided with the theory of military aviation during World War II. Military robot theories are becoming realities. The theories of the 1990s have been surpassed, and with exponential advances in technology, theories are tested and proven viable within a few years, if not months of conception. The most detrimental factor delaying the process is economic, and the necessary pace of the Defense Acquisition Process.

The Demand for Military Robots Equals the Capabilities of Military Robots

The demand for military robots has increased markedly in the past fifteen years. The conclusions drawn by reviewing casualty aversion literature do not point directly to a desire on the part of the American public to use military robots in lieu of soldiers, sailors, airmen, or Marines in order to avoid casualties. Indeed, many of the studies from the past fifteen years point toward a willingness to accept casualties depending on the seriousness of the cause. Therefore, there must be another reason that military robots have become a steadily-increasing part of the American military landscape.

Instead of using military robots in large-scale conventional wars, the administration and the strategic level military leadership sees military robots as useful tools in wars for limited aims.

This serves two basic purposes. First, it limits the visibility of such wars in the American livingroom and coffee house. Robots allow a certain amount of anonymity to military operations – nobody in America is related to a robot that was destroyed on the battlefield, and there are no memorials to lost robots during Memorial Day or Veterans Day. Military robots are basically expendable for any cause, unlike humans who are only expendable if the cause is considered great enough that the public will support it.

The second reason for the increased demand for military robots is related to the first and is best described by historian Geoffrey Parker. He argues that there is a specific western way of war, the first tenet of which is to make up for inferior numbers with a reliance on technological solutions.[101] With dwindling budgets and decreasing manning across all the armed forces, military robots offer a cost-effective means of applying American military power across the globe. Robots do not require the in-theater support systems that humans do, they do not need the training and education that humans do, and there is no need to notify family members when a military robot is lost on the battlefield.

For these two reasons, military robots are increasingly in demand by high-ranking military and political leadership. Military robots are the answer to the equation that Hugh Smith proposed in 2005, that casualty aversion is inversely proportional to core national interests. In a large-scale conflict with direct influence on United States interests, robots are useful, but the American public is willing to incur human casualties to guarantee success. In a small-scale military action only tangentially related to national interests, the usefulness of military robots rises.

The following chart plots a theoretical relationship between willingness to take casualties and the need for military robots. Assuming that the scale of a war is directly related to the consequences of losing that war, the following logic applies. First, the willingness to take

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[101] Geoffrey Parker, ed., *The Cambridge Illustrated History of Warfare: The Triumph of the West* (New York: Cambridge University Press, 1995), 2.

casualties rises as conflict moves from covert to large scale operations, as supported by the studies cited in the literature review of this monograph and the assumption of scale in relation to consequence. However, the need for military robots dips, but then rises again in a large scale operation with dire consequences for American national interests. This is due to an assumed ability for conventional, human forces to accomplish missions in a small scale conventional war. Thus, military robots are necessary to avoid casualties in limited wars; however, they are necessary to support operations in higher intensity conflicts as well. They are not as vital for smaller scale conventional conflicts with few expected casualties.

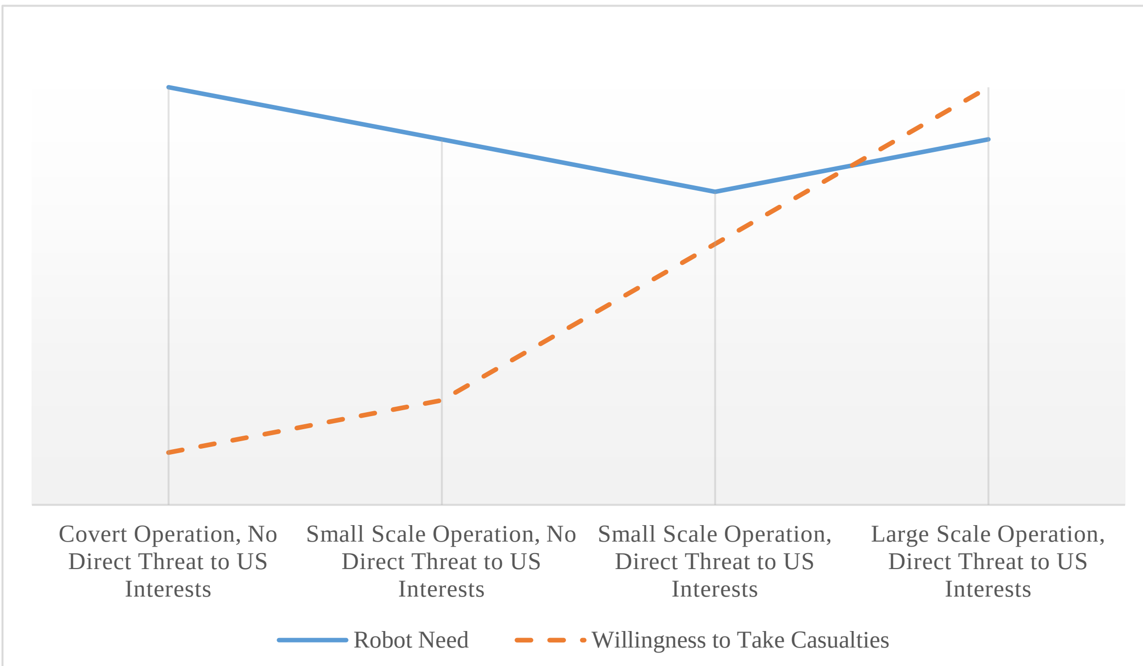

Figure 1. The Relationship of Casualty Acceptance and Robot Need

Source: Original Creation by Author.

Ultimately, the "push" of technology and capabilities of military robots has met the "pull" of desire from both the military and the American public to incorporate fewer troops and more robots on the battlefield, and to use the capabilities that military robots provide to commanders at all levels. This "push/pull" relationship has led to a point where the use of military robots is inevitable, and it will only increase – quickly in the near future, while eventually plateauing over time.

System Integration of Military Robots

As mentioned in the previous chapter, military vehicles must integrate with existing systems in order to be effective. Military robots have effectively integrated into air, land, and sea-based systems, and they are interoperable with most of the contemporary US military inventory. Additionally, military robots are now a consideration during the development of future weapons.

The Way Ahead: How to Incorporate Military Robots at the Operational Level

It is clear that military robots have reached a certain level of capability at the same time as the demand for these robots has peaked. However, there are a few items to consider when planning for the future of military robots. First, the robots will need support systems, some of which are far more intensive than the systems currently in place for manned platforms. Second, military robots will need to become embedded in American doctrine, so leaders at all levels understand the best way to use their capabilities. Finally, military robots must be understood as full-spectrum systems, able to have effects at the tactical, operational, and strategic levels of war.

Support Systems for Military Robots

One of the benefits of using military robots is the ability to keep humans out of harm's way. However, this benefit is not as great when one considers the support systems necessary to keep most military robots operational. Many of the ground robots used to disarm and neutralize improvised explosive devices in Iraq, for example, needed to be sent back to their manufacturers in the United States for repair.[102] This causes a delay and potentially leaves the unit without an important asset.

The support systems for robots must be integrated directly with the frontline units where the robots work. This has the advantage of keeping the robots available as much as possible, but it

[102] Singer, 27.

has two disadvantages. First, it would require either contracted maintenance or soldiers to fix damaged robots. Second, it requires another level of systems to sustain the robots, and increasingly complex robots will need more and more diverse parts.

Doctrinal Integration of Military Robots

The purpose of Army doctrine is to establish a framework around which leaders and units can build their operations. There is no dedicated military robot doctrine in the Army today. Therefore, there is no specific baseline from which planners and warfighters can begin operational planning. If robots take over specific functions, their tasks will fall into existing doctrine, but that doctrine still needs to consider human-robot interoperability at a higher level.

Military Robots Across All Levels of War

An important consideration when planning for the operational use of military robots is the concept that they have affects across all three levels of war. Much like the "strategic corporal" can impact national goals, so can a military robot. At the tactical level, a UGV can destroy an IED to clear a convoy, and at the strategic level a UAV can decapitate an enemy organization. At the operational level, military robots can have the greatest effect. With the potential to fill any task, military robots will assist from the rear support areas to the front lines.

Potential Pitfalls

The fact that military robots open new opportunities for low-visibility, low-risk operations has a potential downside. If military robots become too effective and efficient, this could lend itself to an overuse of these robots. This is similar to the concept of using cruise missiles to conduct limited strikes against Iraq in 1993, in Bosnia in 1995, and again in Iraq in 1996.[103] The potential for overuse of military robots should not be an issue in the future. Instead, the capabilities provided by military robots simply afford other options for American

[103] Reuben E. Brigety II, *Ethics, Technology, and the American Way of War: Cruise Missiles and US Security Policy* (New York: Routledge, 2007), Part II.

policymakers and strategists. As Mary Ellen O’Connell argued, military robots are simply another type of battlefield weapon, and should be used as such. This is up to the policy makers and strategists to ensure that drones are not used as a stepping stone to over-involvement.

Another potential issue with military robots is the idea that, as Marine Corps General James “Mad Dog” Mattis said, “the enemy gets a vote” and what is cheap and easy to build for the United States is also relatively cheap and easy to build for enemies of the United States.[104] The decrease in price and increase in capability of military robots is universal and not restricted to any particular state or coalition. For less than $1000, a person can buy civilian hardware that allows them to fly an unmanned aerial vehicle over 2 kilometers while using a first-person-video link to see what the UAV sees in real time.[105] Civilians in the United States have armed recreational drones with medium-caliber pistols, and created advanced tracking systems to fire weapons from these drones.[106] This was the height of drone technology twenty years ago, and now it is accessible to anyone with a method of payment and a delivery address to receive the parts.

Military robots are able to perform hundreds of tasks that humans normally perform, but they have two very real disadvantages. First, military robots are unable to interact with people directly, so they remove the face-to-face intimacy that some types of missions require. Second, a large majority of military robots in use today are wielded by the United States, which denies our enemies and, to a certain extent, our allies a feeling of reciprocity.

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[104] James Mattis, quoted on the official United States Marine Corps Twitter feed, June 28, 2013, https://twitter.com/usmc/status/350478995051122688.

[105] FPV Pro, “Professional Grade FPV Systems” (web store, 2016), accessed January 23, 2016, http://www.fpvpro.com/store/.

[106] Hogwit, “Flying Gun” (video of handgun demonstration, July 10, 2015), accessed October 25, 2015, https://www.youtube.com/watch?v=xqHrTtvFFIs; James Higgins, “UAWS Presentation” (video of remotely operated drone mounted gun demonstration, January 11, 2016), accessed January 12, 2016, https://www.youtube.com/watch?v=qo62Le8nQpc.

The lack of reciprocity has caused a public backlash as other nations see it as unfair that Americans are able to wage remote-controlled war from the safety of their own homeland. It may seem like a win-win situation for the United States to wage war from halfway around the world without putting American men and women in harm's way, but there are secondary effects of this method of warfare.

Our enemies can point to our lack of direct involvement as a lack of commitment. If the United States is unwilling to put soldiers or Marines on the ground to fight an enemy directly, it shows not only our enemies that we are not fully engaged, but it also gives this impression to the civilians in the conflict area, as well as the international community. The use of military robots is the epitome of Geoffrey Parker's western way of war. It is the United States using its money, technology, and industry to wage indiscriminate war. A lack of American commitment can embolden our enemies and discourage potential local and international support.

The lack of reciprocity can have repercussions for our relations with allies as well. Drone strikes in Pakistan, for example, have caused a backlash against the United States. In a January 22, 2010 *New York Times* article, noted military analyst John Arquilla claimed that the more successful the strikes were, the more the Pakistanis resented the invasion of their sovereignty. Though the short-term military effects were positive, the second- and third-order effects on the population were negative, and potentially much longer lasting.

The Way Ahead

Thus far, most military robots are involved in direct combat operation roles. In these functions, robots have become a common sight and are generally accepted as 'members' of the military. However, there is a broad range of duties that are not yet roboticized. These include logistic support, maneuver space coordination, and medical assistance. These tasks have not been emphasized as much as warfighting tasks like bombing the enemy and disabling explosives, because they are not inherently dangerous to soldiers. By using robots for many of these relatively mundane tasks, humans are freed up to conduct the type of operations that need more discretion or critical thinking. A recent test involving unmanned ground vehicles found that one human operator could control three to five UGVs in a convoy – this allows for six to ten people not to be at risk in a convoy, and makes them available for other missions.[107]

The most intriguing aspect of the future of military robots is the idea of full automation. The capability of strategic bombers to carry nuclear weapons was not a monumental change to military aviation's capabilities. However, it had a huge impact on how the Air Force was perceived by Congress, by the American people, and even by the Air Force itself. The same holds true for fully autonomous military robots. The capability of an autonomous MQ-9 Reaper is not different from a remotely-pilotd Reaper – each carries the same payload, has the same range, and can see the same targets. However, by taking a human out of the decision cycle, the fully-autonomous Reaper becomes far different.

Conclusion

Technology and warfare have been intertwined since the dawn of man. From longbows to machine guns, horses to tanks, and balloons to jet aircraft, the need for battlefield supremacy has driven technological advances for centuries. Military robots are the "next big thing" in warfare. These robots can replace humans in many tasks, both dangerous and mundane. This allows for fewer battlefield casualties, which appeals to the American public. It also allows for fewer human personnel overall, which appeals to the budgetmakers. Robots are capable, accepted, and can affect all three levels of war. They truly are the way of future warfare.

[107] Noah Zych et al., "Achieving Integrated Convoys: Cargo Unmanned Ground Vehicle Development and Experimentation," *Proc. SPIE* 8741, Unmanned Systems Technology XV, 87410Y (May 17, 2013); http://dx.doi.org/10.1117/12.2015586.

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