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The use of robots by the U.S. military has grown exponentially in the last 10 years. While remotely piloted drones and ground vehicles are in the spotlight today, the Department of Defense (DoD) has stated a goal of increasing the level of automation in unmanned systems.[1] Based on pre-existing autonomous systems, the DoD goal, and ongoing technological advances in artificial intelligence it seems likely that automated lethal robots will soon be available to operational commanders for use in combat. While autonomous lethal robots promise significant rewards, they also bring with them significant risks to the success of military operations. Military planners should choose to use autonomous lethal systems when the importance of casualty reduction outweighs the importance of avoiding strategic communications setbacks due to collateral damage.

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SHOULD WE TURN THE ROBOTS LOOSE?

by

Jesse Hilliker

LCDR, USN

A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

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Abstract

The use of robots by the U.S. military has grown exponentially in the last 10 years. While remotely piloted drones and ground vehicles are already in the spotlight today, the Department of Defense (DoD) has stated a goal of increasing the level of automation in unmanned systems.[1] Based on pre-existing autonomous systems, the DoD goal, and ongoing technological advances in artificial intelligence it seems likely that automated lethal robots will soon be available to operational commanders for use in combat. While autonomous lethal robots promise significant rewards, they also bring with them significant risks to the success of military operations. Military planners should choose to use autonomous lethal systems when the importance of casualty reduction outweighs the importance of avoiding strategic communications setbacks due to collateral damage.

Introduction

In 2001, Congress passed the Floyd D. Spence National Defense Authorization Act (Public Law 106-398) which mandated two milestones for military robots, "first, that by 2010, one third of the aircraft in the operational deep strike force should be unmanned, and second, that by 2015 one third of the Army's Future Combat Systems operational ground combat vehicles should be unmanned."[2] Thus was born the ongoing explosion in use of unmanned robotic technology by the U.S. military. Since the passage of Public Law 106-398, more than 6,000 Unmanned Ground Vehicles (UGVs) have been procured and deployed to Iraq and Afghanistan.[3]

In implementing Congress' mandate, the Department of Defense published the *Unmanned Systems Roadmap*, which established several goals including: "Support research and development activities to increase the level of automation in unmanned systems leading to appropriate levels of autonomy, as determined by the Warfighter for each specific platform."[4] Thus, the *Unmanned Systems Roadmap* makes development and employment of automated robots a goal while recognizing that it is not appropriate for all missions.

However, the use of autonomous lethal robots brings additional risks. Robots will make errors despite the best intentions and design. Much like the humans by whom they are designed, robots can be spoofed or manipulated and can make mistakes. Incidents involving improper application of lethal force by robots should be expected to have a disproportionately large adverse effect on the strategic communications efforts of the operation. Military planners should choose to use autonomous lethal systems when the importance of casualty reduction outweighs the importance of avoiding strategic communications setbacks due to collateral damage.

Why is this operational?

A commonly used and debated phrase among military professionals is "strategic corporal". This phrase highlights that important decisions are being made at the junior NCO level and these decisions, right or wrong, can have strategic consequences. In the 2010 military environment where counterinsurgency efforts demand winning the hearts and minds of the population and a camera waits around every corner, the mistakes of a few junior soldiers can have huge adverse effects on the success of the operation.

Enter into this environment a new breed of corporal, tasked to make these same sort of decisions that can have strategic consequences if the decision is incorrect. This new corporal is an autonomous robot that has been programmed with artificial intelligence to make decisions about if and when lethal force can be used without human interaction (no man in the loop). And this corporal is armed with a weapon and the unflinching readiness to use it. If this new breed of soldier improperly applies lethal force, enemy propaganda and news reporters will race to break the story about the American robot that went rogue. The negative impact of such mistakes could have disastrous consequences for the strategic communications effort and therefore on the success of the operation.

Therefore when deciding which forces are to be used to pursue an objective, operational planners must carefully consider the risks and rewards of their use and ensure that they are choosing the right forces to meet their objective. Additionally operational planners must ensure that decisions about the employment of these forces are made at the correct level.

Background

Use of robotic systems over the last decades has proven that robots can significantly contribute to the success of military operations. However, the DoD's *Unmanned System Roadmap* states that, "…these successes, however, likely represent only a fraction of what is possible and desirable by employing unmanned systems."[5] As the DoD looks to increase its use of unmanned robotics systems and simultaneously looks to increase the automation of the robots in use, the robotics industry is churning to design, develop, and produce the systems. This has led to what one source describes as a "technological stampede for cool stuff" which unfortunately leads to roboticists designing machines from a technological perspective rather than a human systems or mission capability perspective.[6] The *Unmanned Systems Roadmap* has identified the rapid pace of advancement as a challenge to future success, stating that, "the development of unmanned system requirements that are driven by what is demonstrated by vendors rather than vendors developing systems based on DoD requirements."[7] Thus there is an acquisition challenge in making sure requirements are driving design instead of vice versa.

The operationally relevant portion of this challenge is understanding that the requirements and capabilities of these systems are still being developed and that the capabilities of these systems may or may not match those required for a specific operation. Therefore operational planners must carefully weigh the risks and rewards of these systems with the understanding that they may have performed very well in some roles but may be poorly suited for others. The *Unmanned Systems Roadmap* states that the appropriate level of autonomy must be determined by the warfighter,[8] and this paper should arm the planners that support the warfighter with the knowledge to make such determinations.

Definition of autonomous lethal robots

In order to frame this discussion it is important, though not easy, to define the terms being used. There are several ways to define the word “robot”. While some definitions use terms like “humanlike” and “operates automatically”, others attempt to define a robot by what it does. Robotics expert and defense consultant Peter Singer defines a robot as a machine that senses, processes, and acts.[9] Specifically a robot must be able to sense or detect things or conditions in its environment, perform some sort of processing to determine a reaction to that condition, and then use some sort of “effector” to alter its environment. Sensing can use many portions of the electromagnetic spectrum (radar, IR, visible light, laser) to detect an item or condition of interest. Processing could entail a wide range of artificial intelligence, used to turn the sensory inputs into a command to use an “effector”. “Effectors” are anything that the robot uses to influence its environment, from a searchlight to a robotic claw to a Hellfire missile. Thus a remote controlled airplane would not be a robot as it has no sensors and no capacity to make decisions. Conversely a remotely piloted drone (such as a Predator), even though it defers most decisions to its operator, can fly itself automatically while “sensing” and “effecting” militants in the tribal regions of Pakistan and thus could be defined as a robot.

Lethal robots are those armed with the means to kill humans. This would include both robots specifically designed for close quarters combat against humans (armed with shotguns, machine guns, etc.) and those with a kinetic warhead designed for destruction of enemy infrastructure (drones designed to find and destroy enemy air defenses). Robots would be non-lethal if armed only with cameras or with non lethal weapons such as Tasers.

Finally it is important to define the term autonomy. The Department of Defense has defined 10 distinct levels of automation.[10] Peter Singer describes seven distinct levels of automation that include “direct human operation”, “human assisted”, “fully autonomous”, and “adaptive.”[11] Thus a remotely piloted vehicle demonstrates the lowest level of autonomy as most or all of its “processing” is done by its human controller. This means that the remotely piloted drone missions being flown today, where the remote operator commands weapons release, would be a “direct human intervention” lethal robot as opposed to an “autonomous lethal robot”. With increasing levels of autonomy, a human goes from a direct operator to an assigner of automated tasks to an observer of automated activity. It is important to note that even the highest levels of autonomy have human interaction. The iRobot Scooba floor cleaner is an example of an autonomous non-lethal robot. The Scooba is a commercially available floor cleaning system that requires a human to designate an area of operations via either mechanical limits such as closed doors or electronic limits such as iRobot “walls” and to initiate its cleaning cycle by pushing a button. At that point it requires no further human interaction as it uses a preprogrammed pattern and obstacle recognition to autonomously clean its designated area. The “fully autonomous” Harpy drone, one of the few autonomous lethal robots ready for use today, still needs human direction. Prior to launch, it requires human input to determine the desired area of operation and what types of targets it should locate and destroy. Post launch it operates in a fully autonomous mode as it flies to its commanded area of operations, locates its target, and attacks its target. For the purposes of this paper, the level of autonomy in question is whether the robot has been given the decision to use lethal force, the “decision to pull the trigger.”

Therefore an autonomous lethal robot is a machine that can sense its conditions, can make an independent (no human intervention) decision about the use of lethal force, and then can apply that lethal force using its own effectors.

Is this just science fiction?

To clarify with readers that such systems are not just something in a science fiction movie, autonomous lethal systems exist today and some are deployed for use today. Two older examples of autonomous lethal systems are the Phalanx shipboard self defense system and the Tomahawk land attack missile. The Phalanx is capable of "autonomously performing its own search, detect, evaluation, track, engage, and kill assessment functions."[12] The Tomahawk land attack cruise missile flies a preprogrammed route and uses digital scene mapping to confirm and attack its target.

More recent examples of autonomous lethal systems with more robot-like qualities are the Harpy attack drone and the SGR-A1 security guard robot. The Harpy is a small aerial drone produced by Israel and designed to provide an autonomous, 'fire-and-forget' Destruction of Enemy Air Defenses (DEAD) capability. Harpy flies a preprogrammed route over the ground using its onboard passive radar receiver to detect enemy air defense targets and then flies itself into the target where it detonates its 32 kg high-explosive warhead.[13] It requires no man in the loop oversight and makes its own decisions about what constitutes a valid target. The SGR-A1 is a robotic security guard produced by Samsung and deployed in the South Korean Demilitarized Zone. It can detect, identify, and engage targets in the Demilitarized zone in either a semi-autonomous mode (which requires human consent to use of lethal force) or autonomous mode (in which the SGR-A1 makes the decision regarding the use of lethal force).[14] The autonomous capabilities of these machines establish that autonomous lethal systems have arrived and demonstrate the urgency of the discussion about how they should be used.

Rewards of autonomous lethal robots

In seeking a balance of risks and rewards, we must consider both the positive and negative aspects of employment of these systems. The rewards of the use of robots have been amply demonstrated in Iraq and Afghanistan. Several books and articles on robotics tell the story of a Navy Chief Petty Officer writing a letter home after one of his best Explosive Ordnance Disposal (EOD) technicians was killed while attempting to disarm an Improvised Explosive Device (IED) in Iraq. The Navy Chief was relieved to be sending the letter to a robotics company in Boston instead of a farmhouse in Iowa.[15] This highlights that the most important reward of the use of remotely operated or autonomous systems is the reduced human exposure to danger and reduced risk of human casualties.

Remotely operated vehicles and robots are generally used to perform work that falls under the three “Ds”- dangerous, dull, dirty.[16] Dangerous work, such as disarming explosive devices or manning fixed checkpoints, exposes humans to potentially deadly forces. Dirty work, such as operating in areas suspected of chemical or biological contamination, exposes humans to environmental agents that are unhealthy. Dull work, such as persistent surveillance of a static position, overwhelms the limits of human attention. In these areas, the limits of human physiology put humans at risk of mission failure or bodily harm. In these areas, the use of robots has blossomed.

One reason robots enjoy a significant advantage over humans in "dangerous" work is that they contain no emotional requirement for self preservation and the associated legal concept of self defense.[17] Specifically, Peter Singer quotes an Army robot operator describing his thoughts on his robot under fire: "The SWORDS (Special Weapons Observation and Reconnaissance Detection System) doesn't care when it's being shot at. Indeed, it would like you to shoot at it. That way we can identify you as a valid target and engage you properly."[18] Unlike a human, who would very rarely "like" to get shot at, a robot has no instinctual urge or legal obligation to defend itself. Therefore it can hold fire when getting shot at and even when getting hit, until target identification is certain.

An additional facet of the robot's lack of self preservation is the lack of short term and long term emotional response to combat. Robotics consultant Ronald Arkin provides a significant data about the propensity of human soldiers to commit and tolerate battle field atrocities. He then details some adverse emotional conditions that cause human soldiers to commit these atrocities including revenge for lost brothers in arms, lack of understanding of the Law of Armed Conflict, frustration, and "bloodthirst" or pleasure derived from the power of killing.[19] Arkin goes on to state that robots and their artificial intelligence could and should be free of these human emotional reactions to the horror of the battlefield.[20] A machine with no emotions feels no fear and no anger and does not change its decision process when under fire. A Pentagon official once summed up robot reaction to combat by saying, "They don't get hungry. They're not afraid. They don't forget their orders. They don't get care if the guy next to them has just been shot. Will they do a better job than humans? Yes."[21]

Robots are capable of fulfilling a wide variety of missions. Their most important contribution is in the three "Ds" where their use can reduce the risk of human exposure to danger. Their lack of preservation instinct allows them to do things that humans don't want to do and commanders don't want their subordinates to do. Therefore the employment of these systems seems very advantageous. However the negative aspects of their use must also be considered.

Risks of autonomous lethal robots

The risk of the use autonomous lethal robots in combat can be reworded into the question, what will be the effect of a robot that improperly employs lethal force? Despite all the advances in robotics technology, robots are not and will never be perfect. An autonomous lethal robot in combat will eventually kill the wrong guy, either a friendly or a civilian.

The history of human interaction with automated systems indicates that automation can reduce mistakes in some tasks, but mistakes will not be eliminated. In 1988, the U.S.S. Vincennes, a guided missile cruiser, deployed to the Persian Gulf. It was armed with the AEGIS weapon system that could automatically detect, track, classify, and engage airborne targets. While transiting the Strait of Hormuz, the AEGIS system detected an air contact that it identified as an Iranian F-14. In its semiautonomous mode, it recommended to its human operators that this target should be engaged with a weapon. The crew consented to the engagement and the Vincennes shot down an Iranian Airbus passenger aircraft.[23] The highly automated target classification and identification system made the wrong call and identified a passenger plane as a tactical aircraft. The humans failed to question the computer's assessment because its automation was so advanced. Together the automated system and its human operators shot down an airliner. More recently, in 2007 an automated South African AAA gun experienced a software glitch during a live fire exercise and "the rogue gun began firing wildly". It continued to do so until it emptied its magazine of 500 rounds of 37mm anti-aircraft shells, killing 9 and wounding 14 others.[24] The human operators were unable to control the gun and several operators were killed in trying to shut it down. Again, the automated system made an unpredictable decision to open fire. These are two examples of automation that hasn't worked as planned and resulted in improper employment of lethal force. Neither one would have been expected by its designer, its operator, or its commander. Peter Singer notes a survey in which 4% of American factories where robots are present have had a "major robotic accident."[25] Additionally, he puts a robotic twist on Murphy's law when he states that the "dark irony is that the more advanced robots get the more complex they become, and the more potential they have for a failure…"

This potential for failure can be compared to the Clausewitzian concept of "fog of war" and "friction."[26] This "friction" could be due to internal factors where small coding errors in the software can have drastic unintended results (reference the South African AAA gun) or to external factors on the battlefield such as electromagnetic interference. Potential sources of electromagnetic interference include everyday signals such as cell phones and Wifi, intentional friendly jamming of IED detonation signals, or enemy jamming of robot datalink. When robbed of its interaction with its human overseer and exposed to electromagnetic signals for which is was not designed, it is difficult to tell what the robots will do. Peter Singer quoted operators of three different robots in use today who said that they have lost control of their robots due to electromagnetic interference. While some robots might just stop, others "drive off the road, come back at you, spin around, stuff like that."[27]

Beyond just losing friendly control of robots, a technologically advanced enemy might even attempt to hack or hijack our robotic warriors. Our current enemies have proven to be very adaptable and have developed simple counters to our battlefield tactics and technology. In December 2009, the Wall Street Journal reported that insurgents in Iraq had hijacked the video feed from a Predator drone. Using a $26 piece of commercial software, they were able to intercept and watch video downlink being used by operational and tactical commanders.[28] Luckily these insurgents were only using the video feeds to avoid military operations. But their ability to intercept robot datalink demonstrates the ease with which robot command and control might be hacked. It is reasonable to suspect that a future threat with a more robust cyber capability would be able to do much more than intercept video datalink. Additionally, insurgents have already demonstrated that they can capture our robots and even use them against us. One American counter-IED robot was captured and was later found in pieces at the site of a bomb blast. Insurgents had re-wired the robot and turned it into a mobile IED.[29] This indicates that our current enemy knows that our machinery can be turned against us. The dangerous next step is the adverse propaganda that our enemy might gain by using a captured robot against civilians. It could be difficult for us to win hearts and minds if an American robot is seen killing people at a marketplace, even if we claim that it was not under our control at the time.

Finally, enemy forces may be able to spoof or deceive autonomous systems, inducing a robot response to suit their propaganda purposes. In *Fast Forward to the Robot Dilemma,* David Bigelow discusses the propaganda implications of a fictitious scenario in which insurgents induce a robot to shoot and stage a martyr to jump into the robot’s field of fire at the last minute.[30] The insurgents set up the engagement to ensure that it appeared that a robot had killed a civilian bystander. In the article a thorough investigation eventually exposed the planned martyrdom, but the initial uproar had the United Nations investigating the killings and all robots were sidelined. A different hypothetical scenario by which enemies might be able to spoof a robot would be a technologically advanced enemy who knew the relatively simple design of the Harpy drone. Armed with the knowledge that it senses and guides to radar energy, a crafty enemy might attach radar emitters to hospitals and school buses in an attempt to induce a Harpy to go after an off limits target, providing a "killer robot" news clip. Finally, insurgents commonly use human shields. Peter Singer relays a story from a Ranger in Somalia who watched "a gunman shoot at him with an AK-47 that was propped between the legs of two kneeling women, while four children sat on the gunman's back. The Somali warrior had literally created a living suit of noncombatant armor."[31] Human shields, radar spoofing, and martyrdom are all means that an enemy might employ to induce a robot to kill apparently innocent bystander.

There are a concerning number of ways in which autonomous lethal robots could kill noncombatants or even friendly forces. Since humans have been making such mistakes in war for thousands of years, it is worth discussing the difference in public perception (and therefore propaganda effect) for a human and an autonomous lethal robot.

Many of our past and present enemies have been masters of propaganda, besting us in strategic communications even if they could not best us on the battlefield. When performing counterinsurgency operations, strategic communications to win the hearts and minds of the population and bolster the popular support among U.S. and coalition nations are a critical component of success. Some examples of military actions that were huge strategic communications setbacks were the Mai Lai massacre in Vietnam and the Abu Ghraib prison situation in Iraq. In both cases, poor decisions were translated into public outrage and eroded public support for continuing operations. The new facet of the strategic communications battle is the introduction of killer robots to the battlefield. Some experts say use of robots will make us look like we turned loose "Terminator" robots, others say they will be regarded as monsters not weapons, and some say that they will be interpreted as a signal of casualty aversion which will encourage terrorism instead of demonstrating military strength.[32] A survey conducted by Ronald Arkin demonstrated that public perception does not find the use of lethal force by autonomous systems acceptable and that the respondents' main concern was the risk of civilian casualties.[33]

The history of robots and automated systems indicates that if autonomous lethal robots are used in combat, they will eventually improperly employ lethal force. After factoring in the media savvy of the current enemy and the adversity of public opinion to robots killing humans, it seems likely that the improper employment of lethal force by a robot will have huge adverse strategic communications impact which could endanger the mission.

Balance of risks and rewards

Operational planners and commanders must balance the risks and rewards of employing these systems. The decision boils down to acceptable risks. Specifically, planners and commanders must weigh the benefits of reduction in U.S. and coalition military casualties against the strategic communications impact of collateral damage to non-combatants. For total war where strategic communications may be less of a consideration, the risks of the use of autonomous systems is low. The mistakes, hacking or spoofing would be considered acceptable collateral damage while the reduction in human exposure to danger would be a powerful reward.

However for operations where total means are not used and avoiding collateral damage is more important than avoiding human casualties, the risks are much higher. The ability to limit human casualties might provide a means to extend public support for a lengthy effort,[34] but the risk of propaganda and strategic communications setbacks could outweigh the benefits. When performing counterinsurgency, maintaining a human in the loop provides the best balance of minimizing human casualties while minimizing risk of providing the enemy with propaganda fodder.

Counterargument

Some would argue that autonomous lethal robots are preferable to human soldiers for all types of combat operations. They would point to the lack of human emotions that can cloud battlefield judgement, the ability to precisely program in rules of engagement into the robots artificial intelligence, and past human responses to advances in technology.

As previously discussed, human emotions such as anger and fear are often encountered in battle and have been shown to cloud judgement and contribute to battlefield atrocities. Robotics engineers would correctly point out that these emotions are not present in their machines and therefore they can make very calculated decisions in the heat of combat.

Robotics engineers would also point out that they expect to be able to program rules of engagement into the artificial intelligence of their robots. Robot consultant Ronald Arkin's book *Governing Lethal Behavior in Autonomous Robots* provides guidance for programming an "ethical governor", a portion of AI that incorporates Rules of Engagement and the Law of

Armed Conflict into mission tasking and sensory inputs.[35] If it operates as designed, it would ensure that all actions taken by the robot would be within legal parameters. Other sources discuss how emotions such as guilt, empathy, joy, or sadness might be designed into a machines AI to make it behave in a more human-like manner.[36] This could give the robot some sense of morality in addition to the legality proposed by Arkin.

From a historical context, it could also be argued the aversion to use of robots on the battlefield is just the latest version of resistance to new technology. It has been likened to the introduction of the tank in World War I which was described as "a weapon of terror, like a large monster, not a weapon."[37] It could be argued that human response to use of robots is no different than that response to when humans first saw guns, trains, cars, or airplanes. The follow on to this argument is that in 50 years we will be kicking ourselves for not jumping on the automated robot train sooner.

However, the technological ability to bypass emotion and program rules of engagement may reduce but does not eliminate the chances of improperly applied lethal force. The Director of the Humans and Automation Lab at MIT has forecast the future of robotics and automation, "…we are going to see a lot of cool technology in various forms of research phases, but we'll also see a lot of failure because many systems won't be designed with the human in mind."[39] Additionally many robotics experts seem to fail to grasp the military consequences of robotic incidents. While American industry may be willing to accept a 4% "major robotics mishap" rate, that same rate of failure may not be acceptable to an operational commander if each robotics incident induces investigations, additional oversight, and a strategic communications setback. While a "beginning dump of physical memory" screen on a PC is usually just a temporary inconvenience, a software or hardware glitch on an autonomous lethal robot has the capacity to turn a tactical operation into an operational or strategic disaster.

Conclusion

Autonomous lethal robots are coming soon. They have been pushing their way toward the battlefield for years and the push will continue as congressional mandates and industry drive us toward increased automation. As operational planners we must understand the risks and reward associated with the use of these systems in order to make sure we choose to use them for the right operations. They are very capable but bring with them a risk of operational setback due to the volatile nature of public opinion on their use. Total war seems to be an appropriate time to use them while counterinsurgency does not appear to be well suited for their use. In all cases operational commanders will want to maintain authorization for their use at the operational or strategic level.

Recommendations

- Operational planners should continue to use robots for "3-Ds" work
- Operational planners should view autonomous lethal robots as one of many forces available for an operation and expect that their use is not appropriate for all operations
- Operational planners should avoid use of autonomous lethal robots when military casualties are more acceptable than collateral damage. Consider use of non-lethal (Tasers in place of guns) or "man in the loop" systems to reduce the risk of a strategic communications setback of robots killing civilians.

- Operational planners should consider use of fully autonomous systems when collateral damage is more acceptable than casualties.
- Operational planners should clarify with the operational commander his intent for authorization of the use of autonomous lethal robots (who can authorize their use).

End Notes

(All notes appear in shortened form. For full details, see the appropriate entry in the bibliography.)

1. U.S. Department of Defense, *Unmanned System Roadmap*, 4.

2. Ibid, 5.

3. Ibid, 3.

4. Ibid, xiv.

5. U.S. Department of Defense, *Unmanned System Roadmap*, 1.

6. Tucker, "U.S. Deploys Unmanned Vehicles."

7. U.S. Department of Defense, *Unmanned System Roadmap*, 40.

8. Ibid, xiv.

9. Singer, *Wired for war*, 67.

10. Valavanis, *Advances in unmanned aerial vehicles,* 537-538.

11. Singer, *Wired for war*, 74.

12. Arkin, *Governing lethal behavior in autonomous robots*, 7-8.

13. Streetly, *Jane's Electronic Mission Aircraft*, 313-315.

14. Arkin, *Governing lethal behavior in autonomous robots*, 10.

15. Singer, *Wired for war*, 21.

16. Ibid, 63.

17. Arkin, *Governing lethal behavior,* 46.

18. Singer, *Wired for war*, 31.

19. Arkin, *Governing lethal behavior,* 33.

20. Ibid, 36.

21. Weiner, "New Model Army Soldier".

22. Arkin, *Governing lethal behavior*, 30.

23. Singer, *Wired for war*, 125.

24. Ibid, 196.

25. Ibid, 195.

26. Ibid, 195.

27. Ibid, 196.

28. Gormon, "Insurgents Hack U.S. Drones".

29. Singer, *Wired for war*, 219.

30. Bigelow, "Fast Forward to Robot Dilemma," 18.

31. Singer, *Wired for war*, 402.

32. Ibid, 311-313.

33. Arkin, *Governing lethal behavior,* 53-55.

34. Singer, *Wired for war*, 221.

35. Arkin, *Governing lethal behavior*, 127.

36. Wallach, *Moral machines*, 155-159.

37. Arkin, *Governing lethal behavior*, 312.

38. Ibid, 30.

39. Tucker, “U.S. Deploys Unmanned Vehicles.”

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