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Robo-Wars

The Regulation of Robotic Weapons

ALEX LEVERINGHAUS
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Executive Summary

The aims of the paper

Future armed conflicts will be characterised by the deployment of military robots and, in particular, robotic weapons. Remotely Piloted Aircraft Systems (RPAS), often popularly known as 'drones', have generated widespread controversy in recent years. Some observers object specifically to the use of RPAS as part of counter-terrorism operations; others are uneasy about the fundamental principle of 'killing by remote control'.

The current generation of RPAS represents the tip of the iceberg of robotic weapons. Samsung's SGR-A1 robots, equipped with two machine guns and a gun with rubber bullets, now 'man' border posts in the Korean Demilitarized Zone.[1] Though currently controlled by human operators, SGR-A1 robots can in principle, once programmed, accurately identify and target individual humans without assistance from a human operator. Last year, the UK Ministry of Defence and BAE Systems announced the successful test of a stealth plane, Taranis. As an object of study, it does not carry weapons and cannot select its own targets but it can, whilst always under the control of an operator, take off, fly to a given destination and find a pre-determined object of interest with little intervention from its operator unless required.[2]

Unfortunately, the emerging debate on robotic weapons is confused. Robotic weapons encompass a variety of systems, some more problematic than others. Furthermore, there is little agreement on the features of robotic weapons which might be deemed legally and ethically problematic. This confusion is compounded at the policy level. Is new legislation to regulate the development and deployment of robotic weapons required? Is robotic warfare inherently unethical, meaning robotic weapons should be banned?

This policy paper summarises different types of military robots and

outlines the relevant technological features of robotic weapons. It provides an overview of the ongoing debates as to whether the use of robotic weapons is legal and ethical. It then assesses current proposals for the regulation of robotic weapons. Finally, the paper makes recommendations to states, manufacturers and the military on how to develop a suitable regulatory framework for robotic weapons.

What are military robots and robotic weapons?

Military robots encompass a variety of robotic systems that are developed for, and used by, the military. One important subgroup of military robots – and the focus of this policy paper - is robotic weapons. Put simply, robotic weapons are armed military robots; they have been designed to carry and deliver a 'payload' aimed at a specific target. One of the most important questions, legally and ethically, is how the targeting process is controlled in a robotic weapon. There are two broad options. In the first, a human operator controls the targeting process via remote control. This is the case with the current generation of RPAS. In the second, once the human operator has programmed the robot with its mission, the robot can carry out the steps of the targeting process without further intervention by a human operator. The BAE Systems Taranis stealth plane and the Samsung SGR-A1 robot may lead the way here. However, BAE Systems has made it clear that, with regard to unmanned aircraft systems, there will always be a need for a human in the loop, in particular regarding any use of weapons, both now and in the future, though it will have to be clarified at what stage of the loop exactly the operator is involved. There are also 'in-between' options, where a human operator may be actively involved in particular steps of the targeting process while other steps are left to the robot, once it has been programmed accordingly.

What is the problem with the current state of regulation?

The regulation of robotic weapons is a complicated undertaking. There are voices in civil society that are calling for a ban on those robotic weapons which, once programmed, do not require a human operator to intervene at the point of force delivery. According to this position, 'automated killing' is neither legal nor ethical. But this claim evokes significant disagreement. The deployment of remote-controlled robotic weapons, where the delivery of the payload is controlled directly by a human operator, has been equally controversial. For example, the deployment of RPAS in recent conflict zones, such as Afghanistan, Yemen,

Pakistan and Iraq, has raised a number of legal questions. Can these systems be deployed in a way that complies with international law? In which contexts is their deployment legal?

Our recommendations in summary

Due to the complexity of the issue, a blanket endorsement or condemnation of robotic weapons is unlikely to be possible at the present stage of technological development. We propose that the regulation of robotic weapons should be pursued on a case-by-case basis.

Recommendations for states

- ***Ensure compliance with legal and ethical frameworks***, guaranteeing that they are taken into account at every stage of the design process; reinforcing that the aim when developing robotic weapons should be enhanced compliance with existing frameworks; and enforcing periodic reviews of new military technologies to ensure compliance.
- ***Analyse risks***, including potential technological risks as well as political and strategic risks.

Recommendation for manufacturers and the military

- ***Design for responsibility***, prioritising human oversight of and control over remote-controlled and autonomous weapons; ensuring operators are able to override the robot at any stage of its deployment; putting in place adequate mechanisms so that individuals can be held responsible for the deployment of robotic weapons; and designing so that machine autonomy is used to enhance human decision-making, not substitute for it.

Recommendation for states and the military

- ***Work together at a national and international level to develop standards of care*** for the deployment of robotic weapons, specifying and delimiting the contexts in which, and the purposes for which, robotic weapons can be used; preventing unconventional uses of robotic weapons (those uses outside the established legal paradigms provided by international humanitarian law and international human rights law); and clearly assigning responsibility for the deployment and supervision of a robotic weapon.

Introduction

Military robotics is an important field within computer-based military technology. Future armed conflicts will be characterised by the increased use of, and reliance upon, military robots. In his excellent book *Wired for War*,[3] the political scientist Peter W. Singer speaks of a robotics revolution that will profoundly affect how the military operates and how wars are fought in the 21st Century.[4]

One of the distinctive features of 'robo-wars' is that, unlike previous conflicts, they will be fought with unmanned or uninhabited weapons. Unlike a tank where a group of soldiers is located inside the vehicle, there are no soldiers inside the robot. In some cases, soldiers may be located thousands of miles away from the battlefield. In this respect, Remotely Piloted Aircraft Systems (RPAS)[5] have attracted widespread attention. In RPAS, a human operator controls the central steps of the targeting process via remote control.

The current generation of remote-controlled robotic weapons is only the tip of the iceberg in the development of uninhabited weapons, and the role of the human operator may well be gradually reduced in future systems. Autonomous robotic weapons, once programmed, will be capable of carrying out central steps of the targeting process without direct guidance from a human operator. An autonomous robotic aeroplane, for instance, may be capable of flying into enemy territory and attacking targets without a human operator having to 'press the button' on a remote control.

As the recent announcement of increased cooperation between the United Kingdom and France on the joint development of military RPAS capability shows, RPAS and other robotic weapons are here to stay.[6] How, then, can policymakers, industry and the military respond to these technological developments? In this paper, we provide answers to this and related questions. To do so, we provide an overview of the main areas in which robots are used by the military; define the key features of robotic weapons; assess the legality of robotic weapons; assess the ethics of robotic weapons; survey current policy responses to robotic weapons; and make recommendations for the regulation of the design of robotic weapons as well as guidelines for their eventual deployment.

1. Military robots

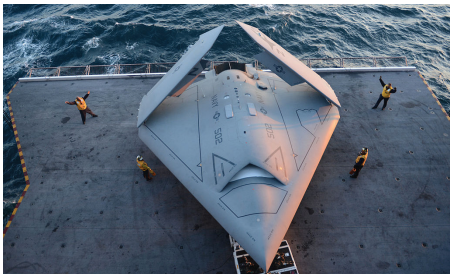
It is unsurprising that robots have found a place in the military. Robots, as roboticists often say, are useful for 'dull, dirty and dangerous tasks' ('the three Ds'). There are many tasks in the military that fit this description, ranging from surveillance and border control to troop support and combat missions. In this section, we briefly outline several examples of specific military robots.

1.1 Dragon Runner

QinetiQ Group (source: Flickr). See https://creativecommons.org/licenses/by-nc-nd/2.0/ for image licence.

- Developed by Carnegie Mellon University and Automatika, Inc
- For use in urban environments
- Can fit into a backpack
- Used by the British Army in Afghanistan for the detection of Improvised Explosive Devices (IEDs) and bomb disposal

1.2 X47-B



U.S. Navy photo by Mass Communication Specialist 2nd Class Timothy Walter/Released.

- Developed by Northrop Grumman
- Uninhabited aerial vehicle
- Once programmed can take off from, and land on, an aircraft carrier without intervention by a human pilot
- Not currently equipped to carry a payload

1.3 Taranis

QinetiQ Group (source: Flickr). See https://creativecommons.org/licenses/by-nc-nd/2.0/ for image licence.

- Developed by BAE Systems
- Unmanned aerial vehicle
- Stealth plane
- Not currently equipped to carry a payload
- Successfully tested by the UK Ministry of Defence and the UK's RAF in Australia in 2013

The images displayed in this section are only a small sample of military robots. There are many other examples which illustrate the huge range of tasks which military robots can undertake. These include the AlphaDog/BigDog, a robotic 'pack mule' to accompany soldiers in difficult terrain, developed by Boston Dynamics. Another example is the SGR-A1, a stationary robot manufactured by Samsung featuring two machine guns and a gun firing rubber bullets. Deployed in the Korean Demilitarized Zone, the SGR-A1 is capable of tracking and identifying targets up to 2.5 km away. Though currently controlled by an operator via remote control, the robot can potentially be operated autonomously.

These robots are indicative of the fact that military robotics is already an important branch of military technology, and that robotics will play a prominent role in armed conflict in the 21st Century. On the one hand, this development may be welcomed, especially when the use of robots protects human life. It is certainly preferable if a robot, rather than a human, is blown up when defusing a landmine. On the other hand, the use of robots for combat raises an even wider set of questions. For this reason, the rest of the paper will concentrate on weaponised military robots.

2. Robotic weapons

In the current debate on robotic weapons, it is not always clear what robotic weapons are, and why they are problematic. In order to provide sound legal and ethical assessments of robotic weapons later in the paper, we tackle the main definitional issues here.

2.1 What is a robot?[7]

There is no agreed definition of a robot, and we will therefore rely on a broad understanding of robots. In a nutshell, robots are artificial devices that can perceive their environment and purposefully act within it. The following features allow them to do this: sensors; artificial bodies, often equipped with artificial extremities, such as arms, legs and wings; motors; and governing software.

2.2 What is a robotic weapon?

There are two key features of weapons that are relevant here. Firstly, weapons are specifically designed to harm, or threaten to harm, another party.[8] Secondly, weapons harm predominantly (but not exclusively) by producing a kinetic effect in order to disable, destroy or kill a target. Carrying a payload, weaponised robots are designed to create such a kinetic effect. Their artificial body, sensors and governing software are engineered to deliver the payload.

In addition, robotic weapons are systems (meaning that there are certain criteria that govern the application of force) and are uninhabited (meaning that there is no operator physically located inside the robot).

2.2.1 Targeting and control

The key question is how the targeting functions of a robotic weapons system are controlled. Targeting processes – or 'Kill Chains' – encompass five steps: observe; orient/analyse; decide; enact; and assess.

In remote-controlled robotic weapons, central - if not all - steps of the Kill Chain are directly controlled by the operator via remote control. Tele-operation, used extensively in current RPAS, is a popular method of controlling robotic weapons.[9]

2.3 Remotely Piloted Aircraft Systems

Tele-operated robotic weapons have a sensor suite that records and transmits images via a radio link. Operators can view these images on a video screen and, based on what they see, issue commands to the robot, again via radio link. Depending on the strength and stability of the link, operators may be located thousands of miles away from the actual area where the robotic weapon is located, while still being able to carry out military acts. As the operator plays an active and direct part by carrying out central steps of the Kill Chain, tele-operated systems are classifiable as 'in-the-loop' systems.

It is worth pointing out that tele-operation reflects the need for high-quality observation

The National Guard (source: Flickr). See https://creativecommons.org/licenses/by/2.0/ for image licence.

and surveillance during armed conflict (and potentially outside it). Indeed, most RPAS are used for surveillance and other forms of information gathering. However, as the case of RPAS shows, the step from a tele-operated surveillance tool towards a weapon is a small one. Here, we focus on RPAS that carry a payload because, in the context of armed conflict, these systems generate more pressing and controversial issues than unarmed RPAS, though this is not to say that the use of surveillance RPAS does not raise important legal and ethical issues.

In contrast to tele-operated 'in-the-loop' systems, autonomous robotic weapons have fully automated Kill Chains.[10] The concept of machine autonomy is contested, and there are no accepted definitions of it. However, the key point is that, once it has been programmed, an autonomous robotic weapon does not require the assistance of an operator in order to attack a target. Unlike remote-controlled robotic weapons, autonomous robotic weapons are either classifiable as 'on-the-loop' systems (where the operator is on standby and can override the robotic targeting process) or 'out-of-the-loop' systems (where the operator is not on standby).[11]

Automation in the military is nothing new. Missile defence systems, for instance, possess high degrees of automation. Yet compared to existing automated systems, future autonomous robotic weapons may have higher levels of Artificial Intelligence (AI); intelligence of a type which, in certain respects, is comparable to that of a human. They also may be able to carry out more complex tasks and operate in more challenging environments than has previously been the case.

The issue of AI points to a crucial challenge for military robotics. Automated systems, with low AI, work very well in restricted and predictable environments; think of a robotic arm on an assembly line in a car production plant. However, the modern battlefield is anything but predictable. In order for an autonomous robotic weapon to successfully navigate the modern

battlefield without constant supervision and guidance by an operator, its levels of AI would need to be higher than those of existing systems. It may take some years in order to develop the levels of AI needed for autonomous robotic weapons, but the development of relevant AI programming techniques is already underway. For example, automated elevator systems and 'smart' electricity grids can already adjust their 'behaviour' based on what they learn; shopping websites use learning algorithms in order to generate profiles of their customers; and NASA's Mars Rover has levels of AI that enable it to navigate Mars' surface without being given constant guidance by an operator via remote control.

It is likely that, firstly, the development of existing AI programming techniques will continue, and, secondly, that these techniques will be utilised by the military and the defence industry. It should also be noted that there are already weapons systems, such as the aforementioned missile defence systems, that have some level of AI. It is thus likely that any steps taken towards autonomous robotic weapons will be incremental, building upon existing and emerging AI programming techniques. Autonomous robotic weapons, therefore, will not constitute a radical break with existing weapons technology.

Autonomous robotic weapons can be placed on a continuum with other existing computer-based weapons systems. But this does not mean that we should be complacent when it comes to new developments in robotic weapons technology. Sometimes even small differences in degree can have major legal and ethical repercussions.

3. Are robotic weapons legal?

In terms of international law, there is no single answer as to whether robotic weapons are illegal. Rather, from a legal perspective, this technology must be capable of satisfying *different* legal requirements under *different* legal regimes. The legal regimes in question are international humanitarian law and international human rights law, as well as rules that regulate the use of force by one state against another (known as 'jus ad bellum'). We begin this section by outlining the relevant legal background and then examine a number of legal issues. These include: the increasingly blurred boundaries between combat and law enforcement operations; the nature and use of weapons; the application of key legal criteria by machines; and legal reviews of weapons.

3.1 The international legal background

In international law, the use of lethal force by the military as well as law-enforcement officials is governed by two different paradigms: the conduct of hostilities paradigm and the law-enforcement paradigm.

3.1.1 The conduct of hostilities paradigm

The conduct of hostilities paradigm is derived from international humanitarian law, which is the body of rules that apply during armed conflict. International humanitarian law aims to protect persons who do not, or no longer, participate in hostilities, such as civilians. In addition, it regulates the conduct of hostilities, referring to the means and method of warfare. However, international humanitarian law does not prohibit the killing or destruction of legitimate targets, provided that a number of rules and principles are respected. It is worth bearing in mind that the conduct of hostilities may, under certain circumstances, entail accompanying loss of life, also known as collateral damage in popular, as well as legal, discourse.

3.1.2 The law-enforcement paradigm

In peacetime, the use of force by state agents is mainly governed by international human rights law, giving rise to the law-enforcement paradigm. The permission to use force under this paradigm is very restrictive; it is only allowed if it is absolutely necessary in order to prevent crime, to effect or assist in the lawful arrest of offenders or suspected offenders, to prevent the escape of offenders or suspected offenders and in quelling riots.[12] In these cases, lethal force may be used only as a last resort in order to protect life.

3.2 Which paradigm should be used?

In contemporary armed conflict – Afghanistan being one of the most prominent examples of the last decade – militaries are increasingly expected to conduct not only combat operations against an adversary (the conduct of hostilities paradigm) but are also expected to conduct law-enforcement operations in order to maintain or restore public security, law and order (the law-enforcement paradigm). Because of this, it is difficult to identify the relevant paradigm

that should regulate the use of force. In addition, a situation of civilian unrest or disturbance can rapidly turn into a combat situation.

Remote-controlled weapons might fare well under those circumstances. RPAS might be able to stay in an area of civil unrest for long periods of time, allowing its operators to carefully observe and monitor the situation before launching an attack.[13] The time afforded could be crucial in determining whether the use of force is necessary, and deciding under which paradigm it should be authorised. Thus, when it comes to monitoring and responding to a rapidly changing environment, the use of remote-controlled weapons may at times be desirable.

By contrast, the deployment of autonomous robotic weapons appears more difficult. Their programming would have to enable them to assess whether a person qualifies as a legitimate target in highly volatile and shifting situations. It would also be necessary to rapidly re-programme autonomous weapons depending on the legal paradigm most appropriate to the emerging situation. If the robot was initially programmed to comply with international human rights law (the law-enforcement paradigm), it would, if the situation changed, have to be re-programmed to comply with international humanitarian law (the conduct of hostilities paradigm).

It might be possible to solve these problems.[14] Firstly, militaries thinking of deploying autonomous robots in these circumstances could simply programme them with the more restrictive of the two frameworks – international human rights law – which could continue to govern their actions even if the paradigm changed. Secondly, militaries could agree that autonomous weapons are only deployed in circumstances that unequivocally fall into one or the other paradigm. Even in conflicts such as those in Afghanistan and Iraq, there are likely to be scenarios that fall clearly into the conduct of hostilities paradigm, rather than the law-enforcement paradigm. Arguably, the use of autonomous robotic weapons should be restricted to the former paradigm. It remains to be seen whether these are feasible options and whether the political will exists to regulate the deployment of autonomous robotic weapons accordingly.

3.3 The nature and use of robotic weapons

In the assessment of weapons, international humanitarian law (the conduct of hostilities paradigm) distinguishes between the use of a weapon and its nature. From the perspective of international law, an AK-47 assault rifle is a lawful weapon. There is nothing in its nature – viewed in isolation from particular uses – that makes it unlawful. However, this is not to say that the AK-47 could not be used in an unlawful manner. It could be used to shoot at civilians. But this does not necessarily make the AK-47 unlawful.

Weapons that are unlawful due to their nature are prohibited because they cause excessive injury or unnecessary suffering that has no military purpose. Unnecessary suffering, in this context, refers primarily to the effect of such weapons on combatants.[15] Weapons in this category include weapons loaded with poison[16], chemical and biological weapons[17] and blinding laser weapons.[18] Since it is not clear that robotic weapons cause excessive injury or unnecessary suffering, it may be reasonable to say that they are not illegal due to their nature, unless they serve as delivery platforms for the aforementioned weapons.

In addition, the principle of discrimination demands that weapon systems that cannot be aimed are also prohibited.[19] More precisely, the principle of discrimination requires that weapons must only be aimed at a specific military target. Weapons that are not capable of discriminate use – of being aimed at a specific military target

– are unlawful. Weapons that are inherently indiscriminate could include: long-range missiles with very rudimentary guidance systems; biological weapons that spread contagious diseases; and anti-personnel mines.[20]

It may be reasonable to argue that neither remote-controlled nor autonomous robotic weapons are indiscriminate in their nature. In remote-controlled weapons, the operator has the ability to make ongoing assessments that allow for the discriminate use of force. Autonomous robotic weapons are slightly more complex. It is possible to argue that these weapons, in the foreseeable future, will not be able to distinguish between combatants/military targets and civilians.[21] But this does not necessarily mean that autonomous robotic weapons are indiscriminate by nature; while they may, in some contexts, be highly inaccurate, there are some environments in which these weapons could be used lawfully. These might include remote areas where no civilians are present, such as the high seas, deserts and outer space. As a result, it is possible to argue that these weapons cannot be banned on grounds that they are indiscriminate by nature.

3.4 Target selection and engagement without human intervention

The legal principles governing the use of force remain the same whether the use of force is carried out by a piloted aircraft, under remote real-time control by a human operator or by an autonomous weapon system without any human control or oversight at the stage of force delivery.

For robots that are remote-controlled by a human operator, the operator determines who is a lawful target and how this determination is to be made. Thus RPAS, in principle, do not raise different legal issues than other piloted aircraft. The engagement of RPAS falls under exactly the same strict military rules as ordinary military aircraft.

Autonomous robotic weapons are more problematic since the robot, though pre-programmed by a human operator, does not function under the direct control of a human operator. In order for the deployment of the robot to be lawful, the machine would have to be programmed in such ways that it can comply with the two key principles of international humanitarian law, namely distinction and proportionality.

3.4.1 Distinction

Under the laws of armed conflict, parties to an armed conflict must distinguish between the civilian population and combatants, and between civilian objects and military objects. Civilians and civilian objects enjoy general protection against dangers arising from military operations, in order that they are not made the object of attack. The principle of distinction poses a number of challenges to autonomous robotic weapons. How would a robot distinguish between a child with a toy gun and a soldier with a machine gun? Would it be possible for a robot to distinguish between a sniper lying on the ground and a wounded combatant, protected under international humanitarian law, who no longer poses a threat? Could a machine also adequately identify a combatant who has expressed the will to surrender and is thus protected under international humanitarian law?

At the moment there are no clear answers to these challenging questions. The burden of proof here falls upon technologists who think that machines can fulfil the above tasks. There is no indication that robots can carry out these tasks, even if AI programming techniques become more sophisticated in the future. An autonomous robotic weapon might be reliable

in identifying a military target with a relatively unambiguous target signature, such as a missile travelling at a certain speed or a radar station that emits distinctive signals. But it is, arguably, highly unlikely that a machine could distinguish between different categories of human individuals in warfare, let alone interpret human behaviour in necessary ways.

The application of the principle of distinction becomes even more complicated when one considers the case of civilians participating in hostilities. In many internal armed conflicts, such as the one ongoing in Iraq, civilians may participate in hostilities. Although international humanitarian law requires that civilians must not be made the intentional target of an attack, civilians who participate in hostilities lose their immunity to intentional attack for the duration of their participation in such hostilities. It is already hard for human combatants to determine when civilians participate in hostilities; civilians often slip in and out of roles, especially in the fluid and dynamic situations witnessed in many armed conflicts. For the reasons given above, it seems unlikely that autonomous robotic weapons could be legally deployed in such scenarios.

3.4.2 Proportionality

The rule of proportionality prohibits an attack if the ensuing civilian harm is excessive in relation to the concrete and direct military advantage anticipated by the attack.[22] An attack may become illegal if excessive collateral damage affecting civilians or civilian objects is to be expected. The concrete application of the rule of proportionality leads to a number of intricate questions. What is the value of a military objective relative to the likely civilian casualties? How many casualties are acceptable in order to eliminate, say, an enemy tank or supply bridge? What is the likelihood that the destruction of a bridge is going to lead to casualties in the school nearby?

Answering these questions requires a number of value judgements that are highly contextual. It is therefore questionable whether autonomous robotic systems can be pre-programmed to foresee the indefinite number of situations in armed conflict that involve value judgements. Relevant judgements require a lot of experience, and military personnel are trained to learn how to make those decisions and calculations.

Advocates of autonomous robotic weapons could point out that military officers sometimes get these decisions and calculations wrong, with highly negative humanitarian consequences. Even extensive training cannot guarantee that military officers never make the wrong decisions. For the case in favour of autonomous robotic weapons to succeed, it needs to be shown that, if we take the imperfect decision-making by humans as a baseline, autonomous robotic weapons could effectively outperform humans.

The key problem is that it is simply not clear how machines, even if AI programming techniques improve considerably over the next two decades or so, could make the necessary value judgements. It is not clear that algorithms could be invented that can cope with this and related questions, especially in shifting circumstances. Should civilian life be measured at '1.5 units' and the destruction of an enemy tank at 'two units', so that the two can be balanced against each other by a machine? And what if the military value of destroying the enemy tank diminishes because of gains on another front? There is little evidence that a suitable matrix could be designed that would enable machines to make these assessments, or that one could assign fixed values to military objectives as well as human lives. Humans may be imperfect in their decision making, but the burden of proof falls upon defenders of autonomous robotic weapons to show that machines could outperform humans.

In the debate on autonomous weapons, it is not clear whether these judgements would really be left to a machine. One can imagine a scenario where a human operator makes the necessary judgements for a particular mission and then programmes the robot with the required information to carry out the mission. In

this case, the robot does not have to make any proportionality calculations itself, as these will have been made by the operator beforehand. According to this understanding of autonomous robotic weapons, the latter can be placed on a continuum with current precision-guided weapons.

Even if we view autonomous robotic weapons as very sophisticated precision-guided weapons, they are not unproblematic. It is questionable whether a robot could carry out complex missions without violating any of the assessments the operator has made. We have already noted that robots would find it hard to distinguish between combatants and non-combatants. Without being able to make this distinction accurately, robots may cause disproportionate damage. Furthermore, circumstances on the battlefield are constantly shifting, which require ongoing judgements of proportionality. This would require direct human supervision.

As we argued above, this does not mean that the deployment of autonomous robots is always unlawful, or that these machines are illegal by nature. Machine-on-machine warfare or the use of autonomous robots in remote areas might still be lawful. However, the scope of the lawful deployment of autonomous robotic weapons is, at present, highly limited.

3.5 Legal reviews of weapons

Under international humanitarian law, there is a general obligation for states to ensure that the employment of new weapons, means or methods of warfare complies with the rules of international law.[23] As a matter of customary law, or as spelt out in Article 36 of Additional Protocol 1 to the Geneva Convention (API), the obligation to conduct reviews applies to every state, whether or not it is party to API, and whether or not it develops and manufactures weapons itself or purchases them. This legal review obligation stems from the general principle that holds that a state's right to choose means and methods of warfare is not unlimited. More precisely, the aim of Article 36 is:

"To prevent the use of weapons that would violate international law in all circumstances and to impose restrictions on the use of weapons that would violate international law in some circumstances, by determining their lawfulness before they are developed, acquired or otherwise incorporated into a State's arsenal".[24]

Carrying out such reviews of new weapons is of crucial importance in light of the current development of robotic weapons technologies. Reviews ensure that armed forces around the world are capable of conducting hostilities in accordance with all relevant international and domestic law. For instance, RPAS have been the subject of legal reviews during the acquisition process, in accordance with the UK's responsibilities under Article 36. One of the reviews concluded that the Reaper drone is capable of being used lawfully and in accordance with the law.[25]

Reviews seek to ensure that a weapon is not indiscriminate and that it would not cause unnecessary suffering or excessive injury. They also determine whether there is any other particular provision under the law of armed conflict which would prohibit the use of the weapon. This means that states are prohibited, on the one hand, from using illegal weapons, means and methods of warfare, and, on the other hand, from using ostensibly legal weapons, means and methods of warfare in an illegal manner.

All robotic weapons, whether remote controlled or autonomous, should be subject to regular legal reviews.[26]

3.6 Concluding assessment

The current legal framework is clearly relevant to the development and deployment of robotic weapons. Neither remote-controlled nor autonomous robotic weapons are currently illegal under the main legal frameworks discussed above, specifically under international humanitarian law. In particular, robotic weapons in themselves are unlikely to be illegal because they are indiscriminate or disproportionate by nature.

That said, while remote-controlled robotic weapons do not, from the perspective of the law, differ from inhabited weapons, autonomous robotic weapons raise a number of issues for international law. Autonomous weapons may, in many situations, be highly inaccurate because they will not be able to identify legitimate targets. Autonomous weapons are also unlikely to carry out assessments of proportionality. These assessments involve intricate value judgements that machines are unlikely to be capable of making, let alone capable of outperforming humans in doing so. Autonomous weapons give rise to considerable legal, technical and military challenges, which means they are unsuited to many contemporary theatres of operation (for example, counter-insurgency operations and law-enforcement operations). Civil wars, humanitarian emergencies and law-enforcement operations are unlikely to offer much scope for the lawful deployment of autonomous robots.

4. Are robotic weapons ethical?

Ethics and law overlap in important respects; both are concerned with the regulation of human behaviour. Within the context of this paper, ethics can provide additional insights on risk, remote warfare, the pursuit of peace and the ethos of the military.

4.1 Robots and risk

Warfare is an inherently risky activity. Once a bullet has been fired, it cannot be stopped. Any ethically sound approach to warfare must take this into account. Not paying attention to potential long-term and short-term risks is negligent because the consequences of our actions matter morally.

4.1.1 Technological risks

The use of force is always risky. While these risks cannot be eliminated, one of the central tasks of the military is to minimise them.

Remote-controlled robotic weapons may be advantageous because they can potentially reduce risks. Indeed, if it can be shown that sophisticated forms of tele-operation enable better control of combat functions than comparable systems, their deployment may even be obligatory. Commonly-cited reasons in favour of remote-controlled weapons, such as RPAS, is that they have sophisticated sensor suites (high-resolution cameras) and can stay in an area for extended periods of time, allowing their operators to gain a better situational understanding than, say, a fighter jet pilot who may only have a very short period of time to review targets and very restricted vision.[27] RPAS, via their communication systems, also allow their operators to consult with military lawyers or their superiors in case of irregularities or disagreements.

Autonomous robotic weapons fare less well from the perspective of risk mitigation. First and foremost, this is because control is ceded to the machine. Furthermore, as noted above, battlefields are complex and constantly shifting environments. It is questionable whether an autonomous weapon would be able to navigate such a battlefield and identify the targets it has been programmed to attack. At the moment, it appears that the deployment of an autonomous robotic weapon would have highly unpredictable consequences, and may thus be excessively risky.

In addition, compared to existing weapons systems, autonomous systems may be more vulnerable to hacking, spoofing and reprogramming by enemy forces. Concerns have already been expressed about the hacking of RPAS. In 2011, for example, Iran claimed to have hacked an American RPAS and stated that its cyber specialists had safely landed it, a claim initially denied by the United States.[28] If loss of control due to enemy action is hard to prevent, the risk of deploying autonomous robotic weapons may be too great to be ethically justifiable. This would especially be the case if enemies were to re-programme robotic weapons in order to commit war crimes, or to attack those who originally deployed them.

4.1.2 Political risks: technological asymmetry and asymmetric war

Robotic weapons may further increase technological and military asymmetries between states.[29] Technologically-advanced states will, arguably, benefit most from robotic weapons technology. In contrast, technologically less-developed states will see their military capacities weakened (in a relative sense). More precisely, it is possible that the capacities of less powerful states to defend themselves effectively against remote and perhaps anonymous uses of force via

robotic weapons is going to be undermined by more powerful states. Policymakers at a national and international level must therefore not merely consider the short-term gains offered by robotic weapons, but also their adverse long-term consequences for the relationship between technologically-advanced and weaker states.

So far, the story of robotic weapons has focused on powerful and technologically-advanced states but it is important, and in the wider interest of global peace and stability, to also assess how robotic weapons impact on the standing of weaker states. Recent conflicts have illustrated some of the negative consequences of pervasive technological asymmetries between enemies.

Experiences of military action in Afghanistan, Iraq and Libya have demonstrated that it is relatively easy for technologically-superior militaries to overpower a technologically-inferior enemy. However, faced with technologically-superior adversaries, combatants from less technologically-developed states (or non-state actors) may find it easier, and more effective, to detonate a primitive IED in an attack on a conventional military target (such as a convoy), or even against a civilian target, rather than pick a fight with an autonomous robotic weapon. In other words, asymmetric responses focus on 'soft targets' (civilian) rather than 'hard targets' (military). This is a particularly worrying development from an ethical and political perspective, because such a response intentionally undercuts the distinction between combatants and civilians.

Furthermore, as witnessed in Iraq and Afghanistan, insurgents often melt into the civilian population, and under these circumstances it is hard to see what advantage robotic weapons could offer. Although it can be argued that remote-controlled robotic weapons might make it easier to counter asymmetric responses by insurgents, for example by providing enhanced surveillance opportunities, the critical question is whether surveillance of enemy territory could be sufficiently comprehensive as to lower the likelihood of asymmetric actions. At the moment, there is no conclusive evidence that it could be. Nor is increased surveillance necessarily in the interest of weaker states, who may find it difficult to protect their territorial integrity and political sovereignty in an age of remote surveillance and weaponry.

To be clear, these problems are not unique to robotic weapons. The worry is that the potential 'roboticisation' of warfare could exacerbate current trends towards technological asymmetries between states as well as broader asymmetric responses in warfare. Considering experiences in Afghanistan and Iraq, armies possessing vastly superior technology are already battling hard to control local insurgencies. It is not clear what would be gained by inserting additional high-tech weapons into these scenarios.

4.2 Deepening distance

Remote warfare relies on increasing the physical distance between one's own troops and the enemy, up to a point where the risk to the former of becoming the target of a counter-attack is greatly reduced, if not eliminated. Many remote-controlled robotic weapons eliminate all physical risks to their operators. Autonomous robotic weapons may be the ultimate remote warfare weapon, as they can operate without direct supervision by a human operator. From the bow to the catapult, from modern artillery to the advent of the aeroplane, technology has led to greater physical distancing between belligerents. Still, robotic weapons have the potential to accelerate and deepen the existing drive towards ever more remote warfare. Therefore, although the practice of remote warfare may not be illegal, it does raise ethical issues.

4.2.1 Killing combatants

Legally, it is permissible to directly and intentionally target individuals who are classified as combatants. The ethical question is why it should be morally permissible to kill combatants in war. One answer is that combatants pose a physical threat, and may therefore be killed by other combatants.

While it is true that individuals who operate remote-controlled robotic weapons, or programme autonomous robotic weapons, do not face any physical threat from enemy combatants, robotic weapons do not necessarily challenge this standard justification of targeting. An RPAS operator based in Lincolnshire in the United Kingdom who launches a strike against insurgents who are firing at British troops in Afghanistan may not be threatened by the insurgents, but defends his or her comrades against a direct physical threat, and his or her actions would potentially be morally justified for this reason.

On the other hand, it is not clear that the targeting criterion of an enemy 'posing a direct and immediate threat' can always be applied to robotic warfare. Recent targeted killing operations in Yemen or Pakistan, in which RPAS have been used, have exposed considerable ambiguities in this area, and may serve as an indicator of future moral problems with robotic warfare. Do individuals who are being targeted in this way pose a direct and immediate threat? And if so, to whom? Or do they pose a remote threat? If so, how can targeting them be justified?

Questions such as these are already pressing, but their importance is likely to increase as some states move towards ever more remote and robotic warfare. It must be clarified in what sense enemy combatants constitute a threat, and whether it is ethically, and not just legally, permissible to kill them using remote weapons.

4.2.2 Who pulls the trigger?

There are well-known accounts of soldiers who have killed a great number of people in war; some have even committed war crimes. Yet we also know of soldiers who were not able to fire their weapon at the enemy. Mercy, pity or compassion, or even sheer abhorrence, may prevent soldiers from pulling the trigger on their weapon. An autonomous robotic weapon, however, *will* shoot if it has been programmed to do so. The taking of a human life is a truly existential choice every human soldier has to justify to his or her own conscience. If a trigger has to be pulled at all, it could be argued that it should be pulled, or not pulled, by a human hand, not a robotic one.

4.3 Robots and peace

War is truly awful. Nevertheless, some ethicists think that it is morally permissible to resist aggression and genocide via force;[30] otherwise peace becomes unsustainable. From an ethical perspective, the use of force must always be viewed in relation to securing peace. What, then, are the implications of the development and use of robotic weapons for peace?

4.3.1 Unconventional uses of robotic weapons: between war and peace

Robotic weapons, perhaps because they are less invasive and more precise than existing weapons, may encourage unconventional uses of force, that is, use of force outside the established legal frameworks discussed above. The danger is that while force may be used remotely, sporadically and in a targeted manner, there is no clear end point for military operations. If this development is accelerated by robotic weapons, the dividing line between peacetime and war will become increasingly blurred. For ethical and legal reasons, unconventional uses of robotic weapons must be discouraged.

4.3.2 The challenge of building peace

Robotic weapons enable relatively small-scale and precise applications of force. However, the 'taking out of threats' with the help of robotic weapons, even if less invasive than a full-scale military campaign, is not equivalent to making peace. Peace-building is an active process that requires considerable efforts, politically and economically. Consider recent experiences in the former Yugoslavia. Large-scale international missions were required to reconstruct Bosnia and Kosovo. Remote and precision weaponry may lead to the illusion that peace comes at little cost, and that the mission has been accomplished once physical threats have disappeared. But this is not the case; the development of robotic weapons, as with any other form of remote-targeting technology, must be complemented by a suitable long-term strategy for peace.

4.4 The warrior ethos[31]

The identity and ethos of soldiers as ethical agents is significantly shaped by the institution of the military and its distinctive values. In the medieval world, the idea of the chivalric knight was important. In modern times, integrity, responsibility and the willingness to incur physical risks as well as to make personal sacrifices has long been part of the warrior ethos. Remote-controlled and autonomous robotic weapons challenge the last two elements of the warrior ethos. Being located thousands of miles from a conflict zone, an RPAS operator does not incur any physical risks when carrying out a mission.

In response, the military must carefully manage the introduction of these weapons into the armed forces. Firstly, service personnel who work with robotic weapons must be fully integrated into their respective service; the military must prevent a gulf opening up between those 'who go out and face the danger' and those who stay behind to operate robotic weapons. This is essential

Bayeux Tapestry – Scene 57: the death of King Harold at the Battle of Hastings.

for maintaining the cohesion of individual services as well as the military as a whole. Secondly, elements of the warrior ethos should be rethought to accommodate the changes brought about by robotic weapons technology. For instance, to compensate for the loss of 'physical courage', it might be necessary to reformulate the rules of engagement to place more weight on responsibility and integrity. This can be supported by changes to recognition and reward systems within the military.[32] One of the greatest challenges for militaries in the 21st Century will be to integrate those who work with robotic weapons and do not have direct physical experience of the theatre of war into the service. Changes to the rules of engagement might, therefore, be inevitable.

4.5 Concluding assessment

Robotic weapons are not unethical as such, but their development and deployment raises a number of substantive ethical concerns. Robotic weapons force us to reconsider justifications for killing in war; this is long overdue. Since these weapons considerably reduce, if not eliminate, risks for those who operate them, we should reconsider whether current targeting criteria remain ethically defensible and relevant in 21st Century warfare.

Autonomous weapons should not be used directly against humans; they should predominantly be deployed in contexts where the likelihood of encountering humans is low. Serious consideration must be given to the long-term impact of robotic weapons on dynamics of armed conflict, and the various technological, political and strategic risks associated with robotic weapons. The development of robotic weapons must be accompanied by a viable long-term strategy for preserving and securing peace. Finally, the introduction of robotic weapons into the armed forces must be well managed; the military must integrate those who work with robotic weapons into the existing structure of the armed forces, and develop adequate roles for them.

5. Current policy responses

There are currently three main policy responses to robotic weapons.

5.1 Preserving the regulatory status quo

One response to robotic weapons is that current legal frameworks do not need to be revised. Advocates of the status quo can take the challenges posed by military robotics seriously. Their point is that there are already bodies of law that should be stringently applied to robotic weapons; the rationale of this approach is to strengthen the application of existing law.

As stated above, robotic weapons are neither inherently indiscriminate nor disproportionate. This is certainly true of remote-controlled robotic weapons. Likewise, automation in warfare is currently not illegal. Unless it can be shown that future autonomous systems will radically differ from current automated ones, it is possible to argue that current international law is capable of regulating 'out-of-the-loop' and 'on-the-loop' systems.

5.1.1 Advantages

This approach opposes unconventional and illegal uses of robotic weapons. It places emphasis on the law and seeks to strengthen the application of existing legal norms. It is crucial that the existing legal framework remains relevant as technology develops.

Article 36 of Additional Protocol 1 to the Geneva Convention already regulates the development of weapons, and requires states to carry out periodic reviews of their weapons to check whether these comply with the law.

5.1.2 Disadvantages

This approach focuses exclusively on the law. Preservation of the regulatory status quo may be justified insofar as the law is concerned, but a sound policy response to robotic weapons cannot be concerned with the law alone. Political and strategic considerations also need to be taken into account. Firstly, these include the risk of blowback (less technologically-advanced enemies may increasingly adopt asymmetrical strategies, including terrorism, in response to the deployment of robotic weapons) and the risk of a robotic arms race (states without robotic weapons will want to catch up)[33]. Secondly, existing asymmetries between technologically-advanced and technologically-weak states might be exacerbated by developments in robotic weapons technology. Finally, policymakers need to also be sensitive towards the impact of robotic weapons on the 'warrior ethos'.

5.2 Ban 'killer robots'

Those seeking a ban on 'killer robots' accept the legality of remote-controlled robotic weapons.[34] However, they argue that the deployment of autonomous robotic weapons does not satisfy international legal standards. It is, for example, unlikely that autonomous robotic weapons, once deployed, will be able to adequately determine whether individuals are combatants or non-combatants. Similarly machines, unlike human combatants, will not be able to assess whether their use of force is excessive in a particular instance. According to critics, this shows that the deployment of autonomous robotic weapons may not respect existing standards under international law. A ban is, therefore, the only option.

5.2.1 Advantages

This approach draws attention to the technological shortcomings of autonomous robotic weapons. Technologists have to overcome tremendous challenges in making autonomous robotic weapons comply with the law. This approach shows that, at the present stage of technological development, there are limited opportunities for the lawful deployment of autonomous robotic weapons. It stresses that ethical considerations are highly relevant to the debate on robotic weapons.

5.2.2 Disadvantages

The concerns voiced in this approach are not sufficient to ban all autonomous robotic weapons. It is unclear how future autonomous robotic weapons will differ from current automated ones; available definitions of autonomous systems could be applied to a wide range of existing systems that are not deemed legally or morally problematic. In some contexts, the use of autonomous robotic weapons could be legal. States that have already invested heavily in relevant weapons research are unwilling to support a complete ban of all autonomous weapons. States could contend that, because future autonomous systems exist on a continuum with current automated weapons, they do not warrant independent legal consideration. Finally, even if it was possible to secure consensus amongst states in favour of a ban, there is a danger that any resulting document would include many gaps and exceptions in order to protect existing automated systems as well as the interests of powerful states in the development of the next generation of autonomous weapons.

5.3 Moratorium

Compared to the call for a ban on 'killer robots', the United Nations Special Rapporteur on Extrajudicial, Summary or Arbitrary Executions, Christof Heyns, made a more moderate proposal in 2013.[35] Accepting the legality of remote-controlled weapons, Heyns recognised that autonomous robotic weapons potentially raise novel legal and moral issues, and contended that research and development should be halted until it has been clarified whether current legal frameworks can effectively regulate the development and deployment of autonomous robotic weapons.

5.3.1 Advantages

This approach reflects the complexity of the issues at hand. The call for a ban may be premature, and this approach potentially appeals to both opponents and advocates of robotic weapons.

5.3.2 Disadvantages

States that have already invested heavily in robotic weapons technology may be reluctant to agree to a moratorium. Furthermore, advocates of this approach remain vague as to which issues need to be clarified, and lack a concrete agenda.

5.4 Where do we go from here?

Each of the three approaches discussed above contains appealing elements. Yet it is clear that none of the three approaches is unproblematic. In this context, we recommend a three-step approach to the regulation of robotic weapons.

5.4.1 Delineate contexts for safe deployment

Governments and militaries, individually and cooperatively, must carefully delineate the particular contexts in which the use of robotic weapons satisfies the key legal criteria of

discrimination, proportionality and necessity. To do this, they must tackle the following three questions: What are robotic weapons for? When is their use legal? When is their use illegal?

5.4.2 Design for responsibility

Militaries must define satisfactory institutional roles for soldiers who work with robotic weapons. It must be clear at all times who, within the chain of command, is responsible for the use of force via robots, be they remote-controlled or automated. Designers of robotic weapons must ensure that the 'actions' of robots are transparent: it must always be clear who programmed the robot and why the robot engaged in certain actions, so individuals can be held responsible for the use of force by the robot within the chain of command. To this end, it might be desirable to install 'black boxes' in military robots that record what the robot does. This would aid the prosecution of violations of the law of war.

5.4.3 Enhance human decision-making

Robotic weapons should be used in order to enhance *human* decision-making. One way to do this is to facilitate greater cooperation between human operators and machines. Rather than creating autonomous weapons that act without the direct supervision of an operator, designers and militaries should harness the power of remote control and automation in order for robots to work with human operators and support them in their decision-making, especially in those situations where operators will face high levels of stress.[36]

6. Recommendations

Given the heated debate on the legality and morality of developing and deploying robotic weapons, their current use in multiple conflict zones and continuous rapid advances in robotic weapons technology, it is vital that policymakers, manufacturers and military leaders reflect on the available regulatory options. Due to the complexity of the issue, a blanket endorsement or condemnation of robotic weapons is impractical. We propose that the regulation of robotic weapons be pursued on a case-by-case basis and, based on the above discussion, we recommend the following actions.

6.1 Recommendations for states

- ***Ensure compliance with legal and ethical frameworks***
  - Guarantee that **existing legal and ethical frameworks** are taken into account at every stage of the robotic weapons design process.
  - Reinforce that the aim when developing robotic weapons should be **enhanced compliance** with existing legal and ethical principles.
  - Enforce **periodic reviews** of new military technologies in order to ensure compliance with legal and ethical frameworks.
- ***Analyse risks***
  - Carry out an extensive analysis of **potential technological risks**, including unpredictability, hacking, spoofing and re-programming by enemy state and non-state actors.
  - Conduct an extensive analysis of **political and strategic risks**, including the adoption of 'asymmetrical methods' by enemy state and non-state actors as a response to the deployment of robotic weapons.

6.2 Recommendation for manufacturers and the military

- ***Design for responsibility***
  - Prioritise **human oversight of and control over** remote-controlled and autonomous weapons at all stages of their deployment.
  - Ensure operators are able to **override the robot** at any stage of its deployment. Genuine 'out-of-the-loop' systems are not desirable.
  - Put in place adequate mechanisms so that **individuals can be held responsible** for the deployment of remote-controlled and autonomous weapons.
  - Design for machine autonomy should be used to **enhance human decision-making, not replace it**.

6.3 Recommendation for states and the military

- ***Work together at a national and international level to develop standards of care***
  - Develop an appropriate **standard of care** for the deployment of robotic weapons. This standard of care must specify and delimit the **contexts** in which, and the **purposes** for which, robotic weapons can be used.
  - **Prevent unconventional uses** of robotic weapons that undercut the standard of care.
  - **Clearly assign responsibility** for the deployment and supervision of a robotic weapon to an individual or group of individuals within the chain of command.

Notes

1 Kumagai, J., A robotic sentry for Korea's Demilitarized Zone, *IEEE Spectrum* (2007), see http://spectrum.ieee.org/robotics/military-robots/a-robotic-sentry-for-koreas-demilitarized-zone (accessed 22/07/2014).

2 Beale, J., Top secret UK drone Taranis makes first flight, *BBC News* (2014), see http://www.bbc.co.uk/news/uk-26046696 (accessed 22/07/2014).

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

4 In discussing 'robo-wars', this paper will not tackle the issue of 'cyber warfare'. So-called software robots share features with 'ordinary' robots, but are used in a cyber or virtual context, rather than on a physical battlefield. As the paper argues, one of the distinctive features of the robotic weapons under consideration here is their capacity to apply kinetic force to a target. Operating in a virtual environment, software robots lack the capacity to use kinetic force (though they may, in certain circumstances, create kinetic effects). It is fair to say that current regulatory frameworks, most notably international humanitarian law, international human rights law and just war theory, are concerned with limiting the use of kinetic force, rather than non-kinetic cyber force. It would be beyond the scope of this paper to offer an analysis of cyber warfare; in order to do justice to the challenges posed by cyber warfare, a separate policy paper is required.

5 Following the terminology of the UK Ministry of Defence, this paper uses the term RPAS. This is more helpful than the term 'drone' because it clearly indicates that the plane is remote-controlled by a human operator. See http://www.raf.mod.uk/equipment/rpas.cfm (accessed 22/07/2014).

6 Wright, O., Britain to set up controversial drone development partnership with France, *The Independent* (2014), see http://www.independent.co.uk/news/world/politics/britain-to-set-up-controversial-drone-development-partnership-with-france-9094412.html (accessed 22/07/2014).

7 Harnessing the work of UK roboticist Alan Winfield, see Winfield, A., *Robotics: A Very Short Introduction* (Oxford: Oxford University Press, 2012).

8 Harnessing the work of the Australian philosopher John Forge, see Forge, J., *Designed to Kill: The Case Against Weapons Research* (Dordrecht: Springer, 2013).

9 Tele-operation is not the only method of controlling robotic weapons. Simple line-of-sight operation with a suitable remote control might also be possible.

10 For a defence of autonomous robotic weapons, see Arkin, R., *Governing Lethal Behaviour in Autonomous Robots* (Baton Rouge: Chapman & Hall, 2009).

11 This terminology is widely used by the US Department of Defense; see Department of Defense, *Unmanned Systems Integrated Roadmap FY 2011-2036* and *Unmanned Systems Integrated Roadmap FY 2013-2038*, available at http://www.defense.gov/pubs/DOD-USRM-2013.pdf (accessed 09/06/2014).

12 United Nations, *Basic Principles on the Use of Force and Firearms by Law Enforcement Officials*, adopted by the Eighth United Nations Congress on the Prevention of Crime and the Treatment of Offenders (1990) and welcomed by United Nations General Assembly Res. 45/166, 18 December 1990, Principle 9 (hereafter: UN Basic Principles on the Use of Force).

13 It is worth pointing out that RPAS were first developed for surveillance and reconnaissance missions. The case of RPAS illustrates that sometimes the step from an unarmed system to an armed one is small.

14 The authors are grateful to Professor Matthew Waxman for the following suggestions.

15 International Committee of the Red Cross customary law, Rule 70.

16 International Committee of the Red Cross customary law, Rule 72.

17 International Committee of the Red Cross customary law, Rules 73 and 74.

18 Protocol IV to the Convention on Certain Conventional Weapons and International Committee of the Red Cross customary law, Rule 86.

19 International Committee of the Red Cross customary law, Rules 7, 12 and 71.

20 The Convention on the Prohibition of Anti-Personnel Mines, also known as the Ottawa Convention.

21 This argument is made by Human Rights Watch, *Losing Humanity: The Case Against Killer Robots* (2012), see http://www.hrw.org/reports/2012/11/19/losing-humanity-0 (accessed 22/07/2014).

22 This principle, found in Article 51(5)(b) of Additional Protocol 1 to the Geneva Convention (API) with respect to international armed conflicts, applies under customary law in non-international armed conflicts.

23 The exact terms of Article 36, API, stipulate that: "In the study, development, acquisition or adoption of a new weapon, means or method of warfare, a High Contracting Party is under an obligation to determine whether its employment would, in some or all circumstances, be prohibited by this Protocol or by any other rule of international law applicable to the High Contracting Party."

24 International Committee of the Red Cross, *A Guide to the Legal Review of New Weapons, Means and Methods of Warfare: Measures to Implement Article 36 of Additional Protocol I of 1977*, page 4 (Geneva: ICRC, 2006).

25 House of Commons Debate, 25 February 2013, see http://www.publications.parliament.uk/pa/cm201213/cmhansrd/cm130225/text/130225w0002.htm (accessed 28/10/2014).

26 This paper will not address the issue of proliferation, but emphasises the importance of relevant legal regulation. For a treatment of the proliferation of RPAS, see Franke, U. E., "The global diffusion of unmanned aerial vehicles (UAVs), or 'drones'" in Aaronson, M. et al (eds.), *Precision Strike Warfare and International Intervention: Strategic, Ethico-legal and Decisional Implications* (London: Routledge, 2014).

27 See Leveringhaus, A. and de Greef, T., "Tele-operated weapons systems: Safeguarding moral perception and responsibility", in Aaronson, M. and Johnson, A. (eds.), *Hitting the Target? How New Capabilities are Shaping International Intervention* (London: Royal United Services Institute, 2013).

28 Moskvitch, K., Are drones the next target for hackers?, BBC Future (2014), see http://www.bbc.com/future/story/20140206-can-drones-be-hacked (accessed 22/07/2013).

29 The authors are grateful to Professor Ian Goldin for raising this point.

30 The classic case is presented by Walzer, M., *Just and Unjust Wars: A Moral Argument with Historical Illustrations* (New York: Basic Books, 1977/2004).

31 Alex Leveringhaus wishes to thank Group Captain Richard Mason (RAF), whose work on the implications of RPAS for the ethos of the RAF he had the privilege of supervising as part of the University of Oxford's Changing Character of War Programme's Visiting Research Fellows initiative.

32 The authors are grateful to Professor Sir Michael Aaronson for this suggestion.

33 It should be stressed that it is the sovereign right of states to develop weapons, including robotic ones. Nevertheless, it is desirable to avoid an arms race.

34 The most comprehensive statement in this regard is Human Rights Watch, *Losing Humanity: The Case Against Killer Robots* (2012), see http://www.hrw.org/reports/2012/11/19/losing-humanity-0 (accessed 22/07/2014).

35 United Nations, *Report of the Special Rapporteur on extrajudicial, summary or arbitrary executions, Christof Heyns* (2013) see http://www.ohchr.org/Documents/HRBodies/HRCouncil/RegularSession/Session23/A-HRC-23-47_en.pdf (accessed 09/06/2014).

36 A more detailed version of this argument can be found in Leveringhaus, A. and de Greef, T., "Keeping the human 'in-the-loop': a qualified defence of autonomous weapons", in Aaronson, M. et al (eds.), *Precision Strike Warfare and International Intervention: Strategic, Ethico-legal and Decisional Implications* (London: Routledge, 2014).

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Future armed conflicts will be characterised by the deployment of military robots and, in particular, robotic weapons. Remotely Piloted Aircraft Systems, commonly referred to as drones, have generated widespread controversy yet the emerging debate is confused. This paper provides an overview of the relevant technological features of robotic weapons; assesses different proposals for their regulation; and makes recommendations to governments, manufacturers and the military on how best to develop a regulatory framework for robotic weapons.

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