Military Autonomous & Robotic Systems

Considerations for the way forward from a UK military perspective[1]

By Wing Commander Guy Edwards

Highly automated robotic systems (often referred to as 'autonomous' systems) will be a significant feature of the future battlespace, potentially leading to a revolution in military affairs. There are many who oppose their development and use on moral, ethical or legal grounds, but this Paper contends that none of the arguments against such systems are truly compelling, and, contrary to the views of most campaign groups, robotic systems are likely to bring many advantages at acceptable levels of risk. However, a clear vision is needed about how to engage with the subject. Failure to engage could result in severe military disadvantage, missed opportunities, weakened national robotics industries, and a marginalizing of nations' views on the ethical use and potential regulation of these systems.

Introduction

> *"The trend is clear: warfare will continue and autonomous robots will ultimately be deployed in its conduct."*[2]
>
> Professor Ronald C Arkin

What is autonomy?

The word 'autonomous' is widely misused and this misuse, far from simply raising semantic issues,[3] creates widespread misunderstanding and leads to public misconceptions and fears about developing capabilities.[4] The word 'autonomous' is derived from the Greek and means 'self-governing'.[5] From a philosophical perspective, Immanuel Kant described autonomy as the ability to impose moral law on oneself.[6] In either construct, an autonomous entity is one that sets its own rules, and this is the commonly understood meaning of the word. Therefore, any system, which is programmed by a human being, assigned a mission by an operator, or deployed on the order of a politician, can never correctly be described as 'autonomous'. In reality, most so-called autonomous systems are highly automated[7] (or 'intelligent'). An earlier attempt by the UK Military's Development, Concepts & Doctrine Centre (DCDC) to define autonomous systems fails to make this distinction[8] and both in US Department of Defense publications[9] and in some NATO documents[10], a variety of definitions of autonomy exist, all of which ignore the literal meaning of the word. Various attempts have also been made to define different levels of autonomy[11] , but almost all have subverted the meaning of the word itself. There are some notable exceptions, for example, the studies into levels of autonomy in robotic systems by Sheridan and Verplanck (1978) and Parasuraman, Sheridan and Wickens (2000), propose ten levels of automation in which the highest level (corresponding to full autonomy) offers the following definition: *'the computer decides everything and acts autonomously, ignoring the human.'*[12] Using this definition, it is impossible to imagine any armed forces wanting to create and use a truly autonomous system.

Autonomous Military Systems

From the forgoing paragraph, it can be deduced that no militaries would wish to develop truly autonomous systems simply because commanders would not want to field systems over which they have no control. Consequently, appropriate levels of control over robotic systems and the ability to direct them, will remain a central principle in the development and acquisition of such systems. Although the US Department of Defense arguably misuses the term 'autonomy', US policy is very clear that *'autonomous and semi-autonomous systems shall be designed to allow commanders and operators to exercise appropriate levels of human judgment over the use of force.'*[13] Similarly, the UK Ministry of Defence (MOD) *"…currently has no intention of developing systems that operate without human intervention."*[14] In short, even for highly-automated and intelligent systems, human oversight remains essential and will continue. This is a crucial deduction in terms of accountability, because if human commanders and operators continue to oversee the deployment and use of robotic systems, then they must surely bear some responsibility for the actions of that system. In light of such assurances of

continuing human oversight, the idea of 'killer robots'[15] running amok, seems entirely fanciful, but it undoubtedly helps to sell newspapers.[16]

Semi-Autonomous and Robotic Systems

Referring to highly automated or intelligent systems as *semi-autonomous* may provide a practical compromise in terminology and serve to reassure those for whom the prospect of robotic military systems is disturbing. Such systems could be described as exhibiting some independent decision-making capability (based on their environment, external stimuli and historical data, and derived from logic processing in accordance with set rules and algorithms). However, such semi-autonomous systems could also allow human intervention, and this could occur at any one of four stages in the system's action cycle (broadly similar to the classic OODA loop[17]), the most obvious case perhaps being the requirement for human authority prior to the use of lethal weapons once the semi-autonomous system had identified a target. While this approach is attractive, it may also be untenable in environments where very fast decision-making is required. It seems more likely that human oversight would be exercised in setting system parameters. Both at the design stage and subsequently, it is important for human operators to understand how a semi-autonomous system is using the information it gathers and thus judge whether intervention or 'manual over-ride' is necessary. Even with high levels of automation, appropriate levels of operator training and workload would be needed for proper oversight. Such oversight would include ensuring that the system is basing its actions on the correct data and that data is being used appropriately. Consequently, the design of cognitive processes for semi-autonomous systems should be comprehensible and preferably, recognizable to human overseers. Roboticist and roboethicist Professor Ronald Arkin of the Georgia Institute of Technology believes that in time, it would even be possible to provide robotic systems with a form of ethical conscience which he describes as an 'ethical governor'. Cognitive frameworks such as those described by Arkin[18] and Thoms[19] may provide the basis of designs for highly intelligent robotic systems. An earlier DCDC assessment opines that *"…unmanned aircraft will eventually have the ability to independently locate and attack mobile targets, with appropriate proportionality and discrimination, but probably not much before 2030."*[20]

Autonomy, Predictability, and Artificial Intelligence

One of the challenges in understanding robotic systems lies in identifying what is, and what is not, an autonomous system. If the literal meaning of autonomy is used, then the task is easy. However, because the term is often used to describe 'highly-automated' actions, there is considerable scope for misunderstanding. This is further complicated by the use of multi-agent systems[21] which interact with each other in order to solve complex problems, but in which the individual elements are likely to have independent functions, priorities or requirements. Although numerous competing definitions exist, in this context multi-agent systems are those systems that include multiple autonomous entities with either diverging information or diverging interests, or both.[22] Bringing these independent entities together in some form of reasoning process is broadly akin to forming a committee to solve a problem. Consequently, the output from a multi agent system may not be predictable and will depend upon design

parameters and constraints as well as the logic algorithms used and external stimuli. Such a system could sense its environment and act accordingly in pursuit of a pre-determined mission. In novel situations, the system is also likely to learn from the outcomes of its own actions – a form of artificial intelligence, albeit limited in what it is permitted to learn. Taken in isolation, the individual 'agents' within a system may be so limited in their function that they could not be considered 'autonomous'. However, combining agents (i.e. a multi agent system) may produce an intelligent system that could be considered semi-autonomous. There is no easily definable point at which this occurs and thus, currently, no straightforward legal delineation between autonomous, semi-autonomous and non-autonomous systems.

Why Robotic Systems would be useful

There are a number of reasons why robotic systems would have military utility.

Reduction of Risk to Personnel

In common with remotely operated systems, semi-autonomous platforms have the foremost advantage of not exposing human operators to dull, dirty or dangerous[23] tasks, or to put it another way, they *'allow their users to project power without projecting vulnerability'*.[24] However, the expense and effort in designing, building and operating semi-autonomous robotic systems should not be underestimated and there clearly has to be a tangible cost-benefit advantage in doing so over and above that of not exposing personnel to risk. Recently however, the UK Supreme Court ruled that the MOD has a duty to ensure that troops are properly prepared and equipped when sent to war.[25] Effectively the ruling upholds soldiers' right to life as described in the European Convention on Human Rights (even in war zones) and arguably places a legal responsibility on the MOD to mitigate risks to soldiers' lives by all feasible means. It could therefore be argued that, where possible, remotely operated or robotic systems should be used in preference to soldiers where a threat to life exists.

Reduced Vulnerability to Electronic Attack or Link Failure

As the reported hijacking of a US RQ-170 Sentinel remotely piloted aircraft in December 2011[26] illustrates, unmanned systems, which rely upon command links or external positioning systems (such as GPS), are inherently vulnerable to communications jamming and spoofing. Even in situations where an adversary is unable to attack command links, the vulnerability of satellite communications gives cause for concern as space weather or debris could cause the loss of critical satellites.[27] Semi-autonomous systems require little or no communications links and can be designed to navigate using only internal references. This mitigates the risk of a successful electronic attack or command link failure due to natural phenomena and thus improves the prospect of mission success.

Speed of Response

Remotely operated platforms incur reaction-time penalties which increase with the distance between operator and platform and whereas these penalties are currently within

acceptable boundaries, as more sophisticated, high speed, and semi-autonomous weapons system are encountered in the battlespace, the time delay due to remote operating is likely to generate unacceptable lag. For example, when defeating enemy missiles operating at supersonic speeds, an unmanned platform will need to react in milliseconds if it is to survive, rather than the 1-5 seconds delay commonly encountered in remotely operated air systems today.[28] Put simply, having a human control such 'survival' responses from a distance would be too slow. Furthermore, even if a command link is over a relatively short distance, the time taken for a human operator to assimilate and act upon inputs may cost precious seconds. Speed also confers improved system survivability due to the difficulty of engaging fast-moving targets: indeed, it is one of air power's core attributes.[29] As westernair forces strive to compensate for the reduction in mass resulting from budgetary constraints, agility and speed become vital in terms of creating momentum or 'velocity' with which to overwhelm adversaries.[30] In a physical sense, remotely piloted or semi-autonomous high speed air systems clearly offer some operational advantages over manned aircraft where high speed, high G manoeuvres challenge physiological boundaries for manned systems. Freed of the need to provide on-board life-support, unmanned platforms may also be smaller and therefore more agile than their manned counterparts.

Ability to Operate Outside of Communications Coverage

Unmanned systems provide a safer alternative than using manned platforms to carry out dull, dirty or dangerous work. In common with remotely operated systems, semi-autonomous platforms also offer the advantages of persistence, constant vigilance and endurance. But for missions or environments where communications links are difficult to maintain (such as underwater mine clearance, or subterranean search and clearance operations), then robotic systems, especially those incorporating multi-agent systems or some form of artificial intelligence, have the advantage of not requiring constant communications links with their operator. Remotely operated robots such as the PackBot[31] and Warrior[32] were used to carry out sampling and basic repair functions at the damaged Fukushima nuclear plant in Japan in areas where radiation levels would have been lethal to humans. However one of the main drawbacks of using them was that wireless control was often impossible due to radio signals being blocked by building structures or degraded by ionizing radiation, and tethering the systems (with fibre-optic control cables) was fraught with difficulties as cables easily snagged on objects and rubble.[33] Whereas the current capabilities of semi-autonomous systems fall well below that required to carry out complex tasks of the type encountered at Fukushima, this is clearly an area where such robotic systems would be of real benefit in the future.

Compliance

One view is that actions should be judged against compliance with regulations or laws rather than against outcomes.[34] As most current generation robots operate on rule-based logic systems they naturally favour such a deontological approach whereby the morality is founded upon the adherence to a rule or set of rules. However, this approach

contrasts to a *consequentialist* one in which *outcomes* rather than rules are all important. Both theories are imperfect: in human terms, it is possible to think of numerous examples where people have meant well and felt justified in ignoring regulations, but the unintended consequences of their actions were extremely negative. The opposite is also true where blind adherence to regulations has given rise to negative consequences, which in many cases, could not have been foreseen by the author of the regulations. In his science-fiction works, Isaac Asimov famously coined a number of *Laws of Robotics*, which in many ways epitomise the deontological approach. However, it is possible to conceive situations in which such 'laws' generate contradictions and could lead to unsafe actions. In short, whichever approach is taken and whether actors are human or robot, there will always be circumstances and decisions, which result in unintended consequences.

What is certain is that human adherence to laws and regulations has frequently failed under conditions of combat stress, extreme provocation or poor leadership. Arguably, pre-deployment training among western forces has greatly improved over recent years and an emphasis on rules of engagement and the Law of Armed Conflict has reduced the number of violations occurring as a result of ignorance. However, basic human nature is unchanged and there is still a high risk of even the best trained troops failing to meet the required behavioural standards.[35]

A 2006 report by the US Surgeon General's Office highlights the compliance challenges facing human beings on the battlefield and the underlying attitudes which give rise to such challenges.[36] Despite over 80% of the marines and soldiers questioned agreeing that they had received training on how to behave towards non-combatants, many had clearly not assimilated the training. The figures below illustrate the problem:

> 17% of soldiers and marines believe that all non-combatants should be treated as insurgents.
>
> 44% of marines and 41% of soldiers believed that torture should be allowed if it saved the life of a soldier or marine.
>
> Only 38% of marines and 47% of soldiers believed that all non-combatants should be treated with dignity and respect.
>
> Only 40% of marines and 55% of soldiers would report a unit member for injuring or killing an innocent non-combatant.

Robots do not suffer from emotional disturbance such as battlefield stress, prejudice or human motives such as revenge, nor are they susceptible to 'scenario fulfilment'.[37] Whilst they may not be perfect, they are highly unlikely to break rules and could also be capable of monitoring and reporting battlefield activity in such a way that would discourage illegal

acts by human combatants.[38] It would also be easier to conduct post-event analysis on a robotic system equipped with 'black-box' recorders. In short, the use of properly programmed robots could significantly reduce the number of breaches of the Laws of Armed Conflict and afford non-combatants greater protection than is currently the case.[39]

Advantages of Robots

Robots do not need sleep or extensive training and they can be designed to operate in extreme conditions: they do not get bored, become inattentive, or experiment with things out of boredom.[40] Their persistence and enduring level of focus on their assigned task easily outperforms human operators and, in a military context, would allow a high operational tempo[41] to be maintained. While robots still require downtime for repair and maintenance, their use may be many times more efficient than using manpower. For example, a simple 24-hour observation and reporting task that might otherwise require three people working in eight-hour shifts will require only one robot. Robots can certainly excel at dull and simple tasks, saving manpower and improving efficiency. But as robot capabilities improve, more complex tasks are also likely to be ceded to robots.

Opportunities

From the foregoing, it can be seen that robotic systems could offer significant advantages in certain military situations. It is worth noting however, that in many situations, robots are unlikely to supplant humans.[42] For example, robots are unlikely to be the best option for roles such as confidence-building, HUMINT,[43] mentoring, and high-level decision-making (especially in novel situations where existing models or metrics are inadequate, or where qualitative judgements are necessary). In much the same way as land, maritime and air forces work together in a highly synergistic way to create joint effects,[44] mixed teams of humans and robots may be the most effective way of harnessing the strengths of both whilst mitigating their respective weaknesses. Robotic systems, if used in a balanced and considered way, could considerably enhance operational effectiveness while improving protection for friendly forces and non-combatants. However, even if the West decided not to invest in the technology, others have understood the potential of such systems and are enthusiastically embracing it - as they have with remotely-operated systems.[45]

Objections to Robotic Systems

Some of the objections to robotic systems mirror those levelled against remotely operated systems (particularly unmanned air systems) but are nevertheless worthy of repetition here along with those that are specific to robotic systems. Many of those who wish to see the development of such systems banned, are perhaps guilty of measuring robotic abilities by what is available here and now, rather than looking to the future. As Arkin puts it: *By merely stating these systems cannot be created to perform properly and ethically does not make it true. If that were so, we would not have supersonic aircraft, space stations, submarines, self-driving cars and the like*.[46]

Legal Challenges

Whilst lethal robotic systems in particular raise significant ethical and legal issues, many of the arguments apply equally to more conventional systems, many of which, to a degree, outraged public conscience when they were first encountered.[47] The Martens Clause[48] is often cited as justification to ban emerging weapons systems stating that [even when no other constraining legislation exists] '*…the human person remains under the protection of the principles of humanity and the dictates of the public conscience*.'[49] Campaigners often suggest that robotic systems violate these principles, however, in practice there are numerous interpretations of the Clause and it is impossible to reach international consensus about *'the dictates of public conscience'*. Consequently, there have been no successful weapons bans under the provisions of the Clause. There is though, a clear danger that technological advances are outpacing regulation and legislation, and as a consequence, there are growing calls for the development of 'lethal autonomous robots' (LARS) to be halted until proper frameworks are in place.[50] Arguably, this is unrealistic considering the relative impotence of the UN and other supranational bodies to enforce a development moratorium, and the vested interests of powerful nations in developing such technologies given their potential military value.[51] However, states party to Additional Protocol 1 the Geneva Conventions (1949) are under obligation, through Article 36, to ensure that new weapons systems do not breach the provisions of the Protocol. *'In the study, development, acquisition or adoption of a new weapon, means or method of warfare,'* states must take steps *'…to limit superfluous injury or unnecessary suffering.'*[52] [53] Consequently, the UK and most other western democracies already review the development of all new weapons to ensure that they do not breach the Conventions.[54] As is so often the case with weapons though, it is *how* they are used, not their *de facto* existence which gives rise to concern.

One of the biggest potential barriers to the lawful use of lethal robotic systems is their current inability to comply with the core principles of *jus in bello* that underpin the Laws of Armed Conflict. The principles are: proportionality, distinction, military necessity, and humanity.

Proportionality

The principle of proportionality imposes a duty not to proceed with an attack which may *'…cause incidental loss of civilian life, injury to civilians, damage to civilian objects, or a combination thereof, which would be excessive in relation to the concrete and direct military advantage anticipated.'*[55] Compliance with the Protocol clearly requires a number of value judgements to be made (e.g. is the expected loss of life excessive? What is the military value of the target? Are there alternative targets, which might produce the same military outcome? etc). These value-based problems are extremely difficult to solve using algorithms alone.[56] However, by seeking to codify such values for use in robotic weapon systems, programmers and lawyers together may evolve a set of objective criteria, which more accurately follows the provisions of international law than is currently the case and which may even be more restrictive.

However, the current Protocol may prove inadequate for regulating lethal robotic systems and a less subjective legal framework may be required.[57] 1977 (when the current Protocol was signed) was, coincidentally, the same year that the first home computers were introduced, and despite exponential developments in computing which have changed the conduct of war, the Protocol has not been revised.

Distinction

The Protocol[58] also provides for the protection of civilians and civilian objects and, as with *proportionality*, the challenges of designing robotic systems capable of discriminating between combatants and non-combatants is immense, but arguably, not impossible.[59] Some commentators make the mistake of assuming that because the *current* generation of robots cannot discriminate between combatants and non-combatants, that they will never be able to do so.[60] Surely though, it is morally wrong to dismiss the potential behavioural improvements that robotic systems could deliver? In combat, human soldiers have to make split-second decisions about whether someone is a combatant or not, something which is made doubly difficult when dealing with insurgents and irregular forces who do not wear uniforms. Ultimately, soldiers have the right to protect themselves and may elect to shoot first when in doubt. For example, a guard might reasonably shoot an approaching person who fails to stop when challenged, provided the guard has reason to believe the person is a suicide bomber concealing explosives and presenting an imminent and direct threat to life.[61] In the heat of battle, a soldier's self-preservation instinct may pre-dispose him to 'shoot-first, ask questions later' if delaying an engagement by a fraction of a second could mean the difference between his life or death. In the 'fog and friction of war', some incorrect decisions by human soldiers are thus inevitable.[62] Robotic systems however, do not face the same dilemma and can take more considered decisions even if, on occasions, this results in their destruction. Most people would agree that the occasional sacrifice of a robotic system is preferable to the death of an innocent civilian. Furthermore, robots have the potential to work in teams with human soldiers, and can be used to determine the intent of unknown actors before situations reach the critical point at which a defensive response is triggered. Finally, even if a robotic weapon system were unable to distinguish between combatants and non-combatants, there would still be circumstances under which it could be lawfully used. *'Not all battlespaces contain civilians or civilian objects. When they do not, a system devoid of an ability to distinguish protected persons and objects from lawful military targets can be used without endangering the former. Typical examples would include the employment of such systems for an attack on a tank formation in a remote area of the desert or on warships in areas of the high seas far from maritime navigation routes'*.[63]

Military Necessity & Humanity

The principle of 'military necessity' provides for the legal use of force to achieve the legitimate purpose of a conflict *with the minimum expenditure of life and resources*.[64]

This is also linked to the principle of 'humanity', which directs the avoidance of *superfluous injury or unnecessary suffering* and the protection of those rendered *hors de combat* such as the wounded or sick.[65] With human soldiers and, arguably even more so for robotic systems, it is often difficult to determine if an adversary is *hors de combat*. There is no hard and fast test and, as history shows us, some soldiers, though badly injured, carry on fighting[66] whereas others with lesser wounds cease fighting. This presents a difficult decision as to whether an injured combatant should be engaged or spared. The answer may lie in technology that both identifies weapons and allows robotic systems to take a 'clean-shot' at the weapon rather than at the person holding it. In future, robotic systems equipped with suitable sensors and having access to weapon databases could feasibly resolve this problem more effectively than their human counterparts. The idea is not new and provides a possible solution to the challenges of the Protocol.[67] [68]

Lack of Accountability

In international humanitarian law, a longstanding interpretation of the *jus in bello* principle includes the idea that someone can always be held responsible for deaths that occur during war. Some lawyers and others (such as philosopher Dr Robert Sparrow) contend that if autonomous systems commit war crimes, no single person or *moral agent* can be held responsible and therefore, the deployment of such systems would be unethical.[69] In considering where responsibility might lie, a number of options are apparent. Responsibility could lie with the robot itself (if it were considered a *moral agent*) but currently, no robots are even close to attaining the sort of Kantian moral agency that would warrant their being considered as wholly responsible for their actions - although some ethicists have argued that, in time, robots will become moral agents.[70] The very term used by Christof Heyns' report (lethal autonomous robots) is problematic. *There is no doubt that machines can deliver lethal force, but in this context autonomy is a relative term. People programme machines and choose how much autonomy to give them*.[71] Therefore, the programmer or designer of the robot could plausibly be held to account for the robot's actions if illegal actions were the result of malfunctioning software or poorly tested algorithms. That said, it seems unlikely that states acquiring and using such systems could be absolved of all responsibility for validating claims about the system's performance. However, given that most programmers work in teams (and that they do so under the auspices of a commercial enterprise), it may be more appropriate to consider such responsibility as a vicarious liability (a principle already extant in law[72]). Governments (rather than individuals) have also been held responsible for 'rogue' weapons systems.[73] However, in common with many other weapon systems, it is often the way in which the weapon is used that determines whether or not it complies with the laws of armed conflict. The decision to deploy a robotic system for a particular mission rests with the military commander and ultimately, therefore, he must share at least some of the accountability for the actions of the robot. It is a weapon system like any other and the commander deploying it must be aware of its limitations,

capabilities, and vulnerabilities and use it accordingly. It has been argued that the commander may not have sufficient technical knowledge to make an informed decision about the reliability of the robot, or may not understand the processes by which the robot makes critical decisions, and thus should not be held responsible. However, examples abound of where commanders do not possess specialist knowledge but instead rely on advisors (for example, on operations, senior UK military commanders are provided with specialist legal advisors[74]) and therefore, if provided with the appropriate specialist advice, there is no reason why the commander should not be held responsible.[75] Prof. Ronald Arkin has hinted at such an arrangement.[76]

The Moral Argument

There is a fundamental moral argument that, no matter how compliant a robotic system is with the various human rights legislation and laws of armed conflict, the sanctity of life is such that robots should never be allowed to take human life. By definition, they lack *humanity*, understanding and compassion, and it is argued that their use in conflict would further dehumanize the grisly business of warfare. As Peter Asaro puts it: *'As a matter of the preservation of human morality, dignity, justice, and law we cannot accept an automated system making the decision to take a human life…When it comes to killing, each instance is deserving of human attention and consideration in light of the moral weight inherent in the active taking of a human life.'*[77] This moral repugnance for lethal robots may be a product of our own self-image as the unassailable prime species and, whilst it is understandable, it is a philosophical point over which there is considerable debate. On the one hand, if robotic systems were so advanced as to possess moral agency, then there is no reason why their decisions should be any less valid (or less moral) than those of a human soldier. Conversely, if they do not possess moral agency, and their actions are devoid of *mens rea*,[78] it is their human facilitators who must remain fully accountable for the way in which they are used (in just the same way as any other weapon system).

Loss of Warrior Ethos

With the advent of remotely operated systems (and, by extension, robotic systems) has come a renewed concern over the loss of warrior ethos and the implications this has for humanity in conflict. Combat in which one party is not risking their life is seen in many cultures as cowardly or lacking in gallantry and, throughout history, there are examples of new weapon systems being introduced, which were deemed unfair, or underhand but which subsequently gained acceptance in warfare (e.g. longbows, artillery, submarines, and aeroplanes). However, modern war is not like a medieval pageant where chivalrous behaviour defines the contest.[79] It is a bloody, and visceral experience and has been characterized thus, *"…remember that no bastard ever won a war by dying for his country. He won it by making the other poor, dumb bastard die for his country"*[80] Indeed, the principle of avoiding direct engagement with an adversary's strength is ages old: '*…in war, the way is to avoid what is strong and strike at what is weak.*'[81]

The warrior ethos is redefined with each generation and while notions of honour, loyalty, integrity, self-sacrifice and courage are still valued and present in modern war fighters, the opportunities to demonstrate them on the battlefield are no longer available to every combatant. Arguably all protagonists who fire long-range or stand-off weapons could be accused of using distance to reduce their exposure to the enemy: this can include artillerymen, submariners and aircrew. Even those who emplace remotely operated improvised explosive devices understand and use the relative safety of distancing themselves from the enemy and eschewing close-quarter combat.

Playstation Mentality

'Playstation' mentality has been conjectured as an effect whereby *'…the geographical and psychological distance between the drone operator and the target lowers the threshold in regard to launching an attack and makes it more likely that weapons will be launched. Operators, rather than seeing human beings, perceive mere blips on a screen*.[82] There is something profoundly distasteful about the thought that taking human life could be compared to computer gaming and, if it were true, it would indeed be cause for concern.[83] However, the decision to launch a weapon is not a personal choice but a calculated decision based on strict Rules of Engagement, which are formulated in such a way as to take full account of the Laws of Armed Conflict. Unfortunately, in common with nearly every other combat situation, examples can be found when rules have been broken (for example, the attack by a Kiowa helicopter, cued by USAF Predator operators, in February 2010 that killed 23 Afghan civilians).[84] The Predator operators were subsequently disciplined for their *"inaccurate and unprofessional"* reporting in what may have been another case of scenario fulfilment.[85] Clearly, the way in which remotely piloted systems are operated does bear some resemblance to the interfaces used for playing console games. Indeed, Predator operators themselves sometimes draw such comparisons, but this does not mean that they approach their business with a gaming mentality.[86] Such an interpretation of their comments is wilfully mischievous. In an interview with *Spiegel International*, P W Singer[87] also dismisses the idea as nonsense: *'In the beginning we feared that drones may make the operators not really care about what they're doing. But the opposite has turned out to be true. They may almost care too much… Traditional bomber pilots don't see their targets. A remote operator sees the target up close; he sees what happens to it during the explosion and the aftermath. You're further away physically but you see more.'*[88] Furthermore, 'drone' operators frequently observe their target area for protracted periods to the extent of recognizing individuals, seeing their families, and understanding the local pattern of life. Talking about a 'Playstation' mentality may be good for sound-bites, but it is little more than propaganda.

Lowering the Conflict Threshold

The justifications for using lethal force are summarized by *Jus ad bellum* criteria,[89] which limit the lawful use of force to situations of last resort. Regardless of the advent of remotely operated and robotic systems, the use of force remains an option of last resort,

the judgement of which rests (in a democracy such as the UK) with elected leaders and not the military. However, more pragmatic considerations have also restrained potential belligerents: national leaders know that armed conflict generally has a heavy cost in terms of life and treasure and may find the consequent political fall-out of conflict unpalatable. Remotely operated or robotic systems mitigate the direct risk[90] and might thus remove one of the perceived costs of resorting to armed conflict. This raises a serious question: *'Is the very possession of the technology leading to decisions to kill in situations where, without it, a non-lethal approach would be taken?'*[91] If we acknowledge that such systems may affect the political decision-making calculus for entering conflict, notwithstanding the provisions of the UN Charter, then it is *'important that the correct policy measures are put in place to avoid this eventuality'.*[92] However, this may be an over-simplistic view, as Alexander Leveringhaus points out: *'…technology in and of itself may enhance military capacities of states. But it is not the only element which decides whether states go to war'.*[93] Ultimately, the decision to resort to force may also depend on the likelihood of retaliation, but where there is an absence of any realistic adversary counter-attack capability, it must be acknowledged that remotely operated and robotic systems do offer the *possibility* of lowering the conflict threshold. The availability of such technology to non-state actors and the possibility of using it anonymously is also likely to lower the conflict threshold.

Accuracy

With respect to remotely operated systems, campaigners often cite a lack of accuracy as a concern, linking it to unnecessary civilian casualties. While many have tried to use the same argument to prevent the development and deployment of robotic or highly automated systems, the underlying premise is fundamentally flawed. Remotely operated and robotic systems are not inherently inaccurate. In common with manned systems, their accuracy is derived from the quality of their onboard sensors, aiming systems, stability, and associated weapons. For example, a Hellfire (AGM-114) missile is no less accurate when fired from a Reaper (remotely piloted aircraft) than it is when fired from an Apache AH-64 (manned) attack helicopter. Arguably, automated or robotic systems may even be more stable during firing due to the removal of imprecise or sudden piloting movements, and might therefore result in better accuracy. Weapons released from remotely-operated systems have undoubtedly caused civilian casualties, but this is often due to poor availability of weapons with small, limited-blast warheads, or a result of Rules of Engagement (and considerations of military necessity) which result in collateral damage[94] being deemed acceptable under the circumstances. This is a value judgement, which is no easier to make whether the system is manned or unmanned, robotic or human. The improved persistence of remotely operated systems (and, in future, robotic systems) and the fact that operators are not in direct danger may afford more time and better support for careful target selection. The result would be greater *tactical patience*[95] than would be possible with a manned platform which may have just fleeting opportunities to attack due to lower endurance and greater risk to the operator if loitering.

> In short, given the right level of investment in sensors and aiming systems, proper design, supporting personnel and the availability of suitable weapons, there is every reason to believe that robotic and highly-automated systems will offer greater accuracy than is currently the case.[96]

Irrational Concerns versus Logical Argument

In short, none of the objections raised provide compelling reasons to abandon or forego the development and eventual use of robotic military systems. Indeed, there seems to be much to commend the responsible development of such systems particularly where their performance exceeds human performance: their use may even improve the lot of non-combatants in conflict and reduce violations of international humanitarian law by combatants. At very least, we should not allow emotive arguments to set the narrative.

Conclusions

Whether we like it or not, highly-automated robotic systems offer militaries many advantages and will inevitably play a major role in future conflicts: they will potentially spark a revolution in military affairs capable of changing forever the face of conflict and the dynamics of military power. An *historic revolution in military affairs is at hand*[97] and those who fail to keep pace are likely to pay a heavy price.

Failure to remain fully engaged with the development of robotic systems would amount to an abdication of responsibility, in commercial, military and ethical terms. Such systems will, without doubt, be increasingly employed in both the civilian and military sectors and may well represent an area of future growth to rival the personal computing or mobile communications booms. Developed nations cannot afford to be left behind. From a military perspective, sitting on the fence while others develop such systems may appear an attractive or even financially prudent option, but such a decision needs to be taken consciously, acknowledging that our ability to influence the ethical and legal constraints on system design or even the logic processes of systems we may wish to buy 'off-the-shelf' at a later date, would be severely limited. Even amongst allies, there are subtle variations in ethical and legal interpretations, which have the potential to drive robotic system development down completely different routes. Furthermore, there should be no doubt, that at some point in the future, there will be a need to counter such systems when they are deployed by adversaries. Arguably, it is even possible (but unlikely) that state-sponsored acts of terrorism could use robotic systems as a means of avoiding attribution.

European Governments in particular[98] could face moral and legal challenges if they knowingly, and without good cause, imperil the lives of their servicemen and women on operations when effective robotic alternatives exist. Arguably, sending human operators to carry out highly dangerous tasks (which could be performed by a robotic system) unnecessarily jeopardizes the operators' lives and may contravene his or her 'right to life' as outlined in European Human Rights legislation. The vanguard of such moral and legal challenges is likely to come sooner

rather than later, particularly in specialist areas such as contamination control and bomb disposal - in both military and civilian operations.

As with remotely piloted systems, there is a real danger that any failure to engage in the debate allows others to set the narrative. This has the clear potential to result in constraints on future use of robotic systems based on fear and prejudice rather than fact. There is also a need for consistency in the use of terminology. Unless we really mean 'autonomous' (as per the English language definition), then we should avoid using the term. If we really mean 'intelligent systems' or 'highly-automated systems', then we should say so.

Existing international protocols were largely designed and written prior to the computing revolution and now appear inadequate in the face of emerging technologies. Governments should consider whether they have an international role to play in leading the development of new protocols or, at very least, being actively involved in the debate.

Robotic systems by design are neither inherently disproportionate nor inherently indiscriminate and there is no legal case for banning them. In common with almost every other weapon system, it is *how* they are used that dictates whether or not their use is legal. Therefore, acknowledging that such systems do possess some novel capabilities, it seems imperative that appropriate additional regulation on *how* they are used should be considered as a matter of urgency, with like-minded states initiating consultations with a view to developing a critical mass of reasoned opinion. Given the evolutionary nature of robotic systems, it may be difficult to define the point at which new regulation becomes obviously necessary. Therefore such regulations need to be in place *before* they are demonstrably required.

Remotely-operated or robotic systems may lower the threshold at which political leaders consider using force. Notwithstanding the underlying *jus ad bellum* imperative that force should only be as a last resort, it may be wise to consider what additional checks and balances could be created to safeguard against such temptations.

At a practical level, semi-autonomous systems already exist and are in service. The boundary between 'fully autonomous' systems and those that are highly automated or intelligent multi-agent systems is becoming increasingly difficult to determine with certainty and there is no clear delineation either in practice or in law. However, within the next decade, commanders will increasingly face situations where they have to decide on the deployment of such systems: at present, they must do so without the benefit of specialist advice. A study should be commissioned now, to determine how this specialist advice would be provided to commanders in the future.

Notes

[1] The views expressed are those of the author, Wing Commander Guy Edwards (UK Ministry of Defence Development, Concepts and Doctrine Centre) and do not necessarily represent

formal UK policy or even a consensus view within the UK MOD. Paper dated 7 September 2013.

[2] Professor Ronald C Arkin: *The Case for Ethical Autonomy in Unmanned Systems*. Georgia Institute of Technology 2010.

[3] *'The distinction between autonomous and automated is important as there are moral, ethical and legal implications regarding the use of autonomous unmanned aircraft'.* UK Joint Doctrine Note 2/11 *The UK Approach to Unmanned Aircraft Systems*. 2011. Page 2-4 para 206c.

[4] For example, see *'Losing Humanity: The Case Against Killer Robots'.* Published by the Human Rights Program, Harvard Law School, 2012.

[5] ***Autonomy*** *n.* ***1****. The possession or right of self government.* ***2****. freedom of action.* ***autonomously*** *having its own laws [from Greek autos 'self' + nomos 'law]'.* Concise Oxford English Dictionary (12th Edition).

[6] Immanuel Kant - Grundlegung zur Metaphysik der Sitten, 1785 (Groundwork of the Metaphysics of Morals).

[7] ***Automatic*** *adj.* ***1*** *(of a device or its function) working by itself with little or no direct human control.* Concise Oxford English Dictionary (12th Edition).

[8] *'An autonomous system is capable of understanding higher level intent and direction. From this understanding and its perception of its environment, such a system is able to take appropriate action to bring about a desired state. It is capable of deciding a course of action from a number of alternatives, without depending on human oversight and control, although these may still be present. Although the overall activity of an autonomous unmanned aircraft will be predictable, individual actions may not be.'* Joint Doctrine Note 2/11 – The UK Approach to Unmanned Air Systems. United Kingdom Ministry of Defence, 2011. p2-3.

[9] For example, the OSD Unmanned Systems Integrated Roadmap FY2011/2036.

[10] For example, the NATO Industrial Advisory Group, Study Group 75, Annex C – Autonomous Operations, 2004 which focuses on the ability of an 'autonomous system' to be 'goal-directed'.

[11] The Autonomy Levels for Unmanned Systems (ALFUS) Framework describes autonomy in terms of the human operator's ability to interact with unmanned systems to perform the **operator assigned** missions. The following modes of operation are defined: fully autonomous, semi-autonomous, teleoperation, and remote control, fully autonomous being '*a mode of operation of an UMS wherein the UMS is expected to accomplish its mission, within a defined scope, without human intervention*. [Compare with OED definition of 'automatic', above.]

[12] For a comparison of the two studies see Robert M Taylor: *Capability, Cognition and Autonomy*. HMSO 2002. p15.

[13] US Department of Defense Directive No.3000.09 *'Autonomy in Weapon Systems'* dated 21 Nov 2012. Para 4.

[14] Lord Astor (The Parliamentary Under-Secretary of State, Ministry of Defence) in a response to a question from Lord Harris of Haringey in the House of Lords on 26 March 2013. He went on to say *"…let us be absolutely clear that the operation of weapons systems will always, always, be under human control."* Reported in the Hansard (Column 955), 26 March 2013. However, it is not clear however whether 'human control' includes the setting of engagement parameters for automated systems.

[15] "Killer Robots" is the pejorative term used by activists who oppose the development of

'autonomous' military systems. The term is widely used to sensationalize autonomous military systems and has gained a degree of traction in the mainstream press.

[16] For example *'Killer Robots Must Be Stopped'* - a headline from *The Observer* on 23 February 2013 (which also carried a photograph of a killer robot from the science fiction film *Terminator 3: Rise of the Robots*. The group behind the headline was the UK-based *Campaign to Stop Killer Robots* (see **www.stopkillerrobots.org**).

[17] The OODA loop: *Observe, Orient, Decide, Act* as described by USAF Colonel John Boyd.

[18] Ronald C Arkin: *Governing Lethal Behaviour: Embedding Ethics in a Hybrid Deliberative/Reactive Robot Architecture.* Georgia Institute of Technology, 2011.

[19] Joanne Thoms: *Understanding the Impact of Machine Technologies on Human Team Cognition*. 2009.

[20] UK Joint Doctrine Note 2/11 *"The UK Approach to Unmanned Aircraft Systems"* p3-6. MOD 2011.

[21] A multi-agent system (MAS) is a computerized system composed of multiple interacting intelligent agents within an environment. Multi-agent systems can be used to solve problems that are difficult or impossible for an individual agent or a monolithic system to solve. (**http://en.wikipedia.org/wiki/Multi-agent_system** (accessed 3 Jun 13).

[22] Shoam & Leyton Brown *"Multi Agent Systems: Algorithmic, Game-Theoretic, and Logical Foundations.* Stanford University & University of British Columbia. 2009.

[23] The MOD's JDN 2/11 pages 3-4 to 3-6 describes dull, dirty, dangerous and deep missions.

[24] Lt Gen David A Deptula USAF (Retd): *Remotely Operated Air Power: Implications for Ethics, Policy and Strategy*. (An Air Power Australia Essay on Military Ethics and Culture). April 2013

[25] *The Supreme Court of the United Kingdom* – Press Summary dated 19 June 2013. (Accessed online at **www.supremecourt.gov.uk/decided-cases** on 16 Jul 2013).

[26] In an exclusive interview with the *Christian Science Monitor* an Iranian Engineer is reported to have claimed that the Sentinel's command links were jammed and then spoof GPS signals fed to the UAV as it reverted to its lost-link recovery routine, tricking the aircraft into landing in Iran. (Christian Science Monitor 15 December 2011 accessed at **http://www.csmonitor.com/World/Middle-East/2011/1215/Exclusive-Iran-hijacked-US-drone-says-Iranian-engineer-Video** on 1 June 2013).

[27] See *The UK Military Space Primer*. DCDC, MOD UK.2010. Chapter 1.

[28] On 5 June 2013, the USMC lost one of its two KMax Remotely Piloted helicopters in Afghanistan in part due to system latency which hindered the response to an underslung load oscillation.

[29] Joint Doctrine Publication (JDP) 0-30: UK Air and Space Doctrine. UK MOD July 2013. Para 106.

[30] Air Cdre P Teakle: *A Step in the Right Direction – The Concept of Military Momentum*. The Journal of the Joint Air Power Competence Centre, Edition 17 (Spring/Summer 2013). Page 58.

[31] See **http://www.irobot.com/us/learn/defense/packbot.aspx**.

[32] See **http://www.irobot.com/en/us/learn/defense/warrior.aspx**.

[33] Eric Guizzo *Fukushima Robot Operator Tell-All Blog* dated 23 Aug 2011. **http://spectrum.ieee.org/automaton/robotics/industrial-robots/fukushima-robot-operator-diaries** accessed 2 Jun 13. The website contains translated excerpts from a blog written by one of the robot operators

at Fukushima and highlights the advantages and challenges of working with robots.

[34] Kant, Immanuel. *Groundwork of the Metaphysic of Morals: Transition from the Common Rational Knowledge of Morals to the Philosophical*. 1785.

[35] For example; The Canadian Airborne Regiment's mistreatment and murder of Somalis during a UN peacekeeping Mission in 1993; the US military's abuse of Iraqis in Abu Ghraib prison during 2003 and 2004 and UK military abuses in Iraq over the same period.

[36] US Mental Health Advisory Team (MHAT) IV. *Operation Iraqi Freedom 05-07 – Final Report. Office of the Surgeon General, United States Army Medical Command*, 17 November 2006.

[37] 'Scenario fulfilment' was a term used by the US Government to describe a psychological response by the crew of the US Navy guided missile cruiser *USS Vincennes* during the shoot-down of an Iranian civilian airliner in July 1988. In a written answer provided to the BBC documentary, *The Other Lockerbie* (screened in 2000), it was postulated that because some of the airliner's flight parameters matched those of possible attack profiles (for which the crew had extensively practiced), they believed the *Vincennes* was under attack and ignored sensory information which contradicted their understanding of the scenario.

[38] See Arkin, Ronald C. *Governing Lethal Behaviour: Embedding Ethics in a Hybrid Deliberative/ Reactive Robot Architecture*. Georgia Institute of Technology, 2011. Page 7.

[39] *'In the not too distant future, relatively autonomous robots may be capable of conducting warfare in a way that matches or exceeds the traditional jus in bello morality of a human soldier.' Lin et al: Autonomous Military Robotics: Risk, Ethics, and Design*. California Polytechnic State University, 2008. p54, 4.7.

[40] There are numerous reported cases of operators conducting unauthorised experiments with systems out of boredom. For example, in 1973 in Albuquerque, a National Airlines DC10 crew experimented with the aircraft's auto-throttle system in such a way that caused an engine to over-speed. The resulting engine disintegration ripped a hole in the fuselage causing an explosive decompression in the cabin which sucked a passenger out of the plane.

[41] *Operational tempo* is the term used to describe the pace and frequency of military operations and may be considered similar to 'momentum'. In most military operations there is also a requirement for an 'operational pause' during which forces are reconstituted, re-armed, refuelled, repaired and rested ready for the next phase of the operation.

[42] See Leveringhaus, Alexander. *Much Ado About Killer Robots*. e-International Relations, 4 June 2013. *('Three Fallacies in the Killer Robots Debate: [No.1] The Military will use Killer Robots in every context and for every conceivable task').* http://www.e-ir.info/2013/06/04/much-ado-about-killer-robots accessed 7 July 2013.

[43] Joint Doctrine Publication 2-00 *Understanding and Intelligence Support to Joint Operations (Third Edition) describes* HUMINT (human intelligence) as *'a category of intelligence derived from information provided by, or collected on, human sources and individuals of intelligence interest, as well as systematic and controlled exploitation, by interaction with, or surveillance of, those sources or individuals.'*

[44] The UK MOD's Joint Doctrine Publication 3-00 *Campaign Execution* (Third Edition, Change 1) describes how the unique capabilities of the 3 environmental services are combined in order to achieve the greatest effect possible.

[45] *Growth in UAV manufacturing and procurement is not limited to the West. China's commitment to unmanned systems in terms of volume is larger even than the United States. The demand for industrial robots is estimated to hit 32,000 units by 2014, making it the world's largest consumer of robotics technology. China has ramped up unmanned systems development faster than any other nation and threatens to surpass the West in technology and capability*. Parsons, D. *Worldwide, Drones are in High Demand.* National Defense Archive. May 2013.
[46] Arkin, R. *Lethal Autonomous Systems and the Plight of the Non-combatant*. 2013. Page 6. http://www.cc.gatech.edu/ai/robot-lab/publications.html accessed 13 Jul 13.
[47] The Second Lateran Council (1123) under Pope Innocent II is often quoted as outlawing the use of crossbows (against Christians) although the actual wording is somewhat vague: *'Slingers and archers directing their art against Christians, are anathematized.'* Ten Ecumenical Council, Lateran II. Canon 29.
[48] The Martens Clause was a preamble to the 1899 *Hague Convention on the Laws and Customs of War on Land* that sought to endow protection on life even where specific cases were not covered by the articles of the Convention itself. However, it is widely accepted in legal literature that the Clause does not constitute a legal criterion in its own right against which the lawfulness of new weapons or methods can be judged.
[49] Modified wording used in the Hague Convention of 1907.
[50] *'The Human Rights Council should call on all States to declare and implement national moratoria on at least the testing, production, assembly, transfer, acquisition, deployment and use of LARs until such time as an internationally agreed upon framework on the future of LARs has been established.'* UN General Assembly: Report of the Special Rapporteur on extrajudicial, summary or arbitrary executions, Christof Heyns. 9 April 2013. Recommendations, para 113.
[51] *'The moratorium Christof Heyns called for is likely to be dead on arrival if it ever gets to the UN Security Council - some veto-wielding nations have no intention of backing away from intelligent-machine warfare.'* Arquilla, J: *Could Killer Robots Bring World Peace?* National Security, 19 June 2013. http://www.foreignpolicy.com accessed 1 July 2013.
[52] *Protocol Additional to the Geneva Conventions of 12 August 1949, and relating to the Protection of Victims of international Armed Conflicts (Protocol 1), 8 June 1977. Article 36 – New Weapons.* http://www.icrc.org/eng/war-and-law/index.jsp accessed 10 July 2013.
[53] Additional Protocol 1 Article 35(2) also states that *"It is prohibited to employ weapons, projectiles and material and methods of warfare of a nature to cause superfluous injury or unnecessary suffering."*
[54] For UK weapons designed for use in international armed conflict, Article 36 clearance is the responsibility of the MOD's Developments, Concepts & Doctrine Centre. (See Defence Instructions & Notices: 2013DIN04-015 (Released February 2013).
[55] Protocol Additional to the Geneva Conventions of 12 August 1949, and relating to the protection of Victims of International Armed Conflicts (Protocol I), 8 June 1977. Article 57 (Precautions in Attack).
[56] *'Although they have not yet been developed, "military advantage" algorithms could theoretically be programmed into autonomous weapon systems. For example, the systems could be pre-programmed with unacceptable collateral damage thresholds for particular target sets or situations.'*

Schmitt & Thurnher: *"Out of the Loop": Autonomous Weapon Systems and the Law of Armed Conflict.* Harvard national Security Journal, Volume 4.2013. Page 256.

[57] In Christof Heyn's report to the UN *(idem)* he makes a similar recommendation: The UN should convene a High Level Panel whose tasks would include an *'…assessment of the adequacy or shortcomings of existing international and domestic legal frameworks governing LARs.'* [Lethal Autonomous Robots] Recommendations A. 114(d).

[58] *Idem.* Protocol - Articles 51, 52 and 57 refer.

[59] See Arkin, Ronald C. *Governing Lethal Behaviour: Embedding Ethics in a Hybrid Deliberative/ Reactive Robot Architecture.* Georgia Institute of Technology, 2011.

[60] Sharkey, Prof. Noel E. *The evitability of autonomous robot warfare.* International Review of the Red Cross, 94 pp 787-799.

[61] For example, the high-profile case of the SAS shooting members of an IRA active service unit in Gibraltar in 1988 was justified as lawful killing on these grounds. *'McCann's [one of the IRA Members] hand moved suddenly and aggressively across the front of his body. Soldier A thought that he was going for the button to detonate the bomb and opened fire.'* UK Law Commission Report Transcript – 4 March 1994.

[62] *'Armed conflict, of any type, is a bloody, chaotic and destructive business. The inherent chaos of war fighting introduces friction, exacerbated when (almost inevitably) initial plans are overtaken by events…'* UK MOD: British Defence Doctrine (4th Edition). Para 526.

[63] Schmitt & Thurnher: *"Out of the Loop": Autonomous Weapon Systems and the Law of Armed Conflict.* Harvard National Security Journal, Volume 4.2013. Page 231.

[64] Described more fully in UK MOD *Joint Doctrine Publication 3-46* (Second Edition). *Legal Support to Joint Operations*. 2010. Page 1-12.

[65] Id. Protocol Articles 35(2), 41 and 45 (especially Article 41(2) which states that: *"a person is 'hors de combat' if: (a) he is in the power of an adverse Party; (b) he clearly expresses an intention to surrender; or 9c) he has been rendered unconscious or is otherwise incapacitated by wounds or sickness, and therefore is incapable of defending himself; providing that in any of these cases he abstains from any hostile act and does not attempt to escape."*

[66] For example, Pte Johnson Beharry VC. *'…a rocket-propelled grenade detonated on the vehicle's frontal armour, just six inches from Beharry's head, resulting in a serious head injury. Other rockets struck the turret and sides of the vehicle, incapacitating his commander and injuring several of the crew. With the blood from his head injury obscuring his vision, Beharry managed to continue to control his vehicle, and forcefully reversed the Warrior out of the ambush area…'* Excerpt from citation in London Gazette, 17 March 2005. Supplement No.1.

[67] 'The same principles that power facial recognition software could apply to robots targeting their weapons at other weapons, so they fire to disable guns and not to kill people.' Atherton, K. *UN Expert Worries about Killer Robots.* POPSCI 31 May 2103. **www.popsci.com** accessed 14 July 2013.

[68] See "ARA Develops the Image Processing Analysis for Weapon Detection System" at **www.ara.com**, accessed 21 July 2013.

[69] Sparrow R, *Killer Robots in The Journal of Applied Philosophy*, Vol.24, No.1, 2007.

[70] *'…it is certain that if we pursue this technology, then future highly complex interactive robots*

will be moral agents with the corresponding rights and responsibilities.' Sullins, J. When is a Robot a Moral Agent? International Review of Information Ethics, Vol.6 (12/2006) accessed at **www.academia.edu** on 20 July 2013.

[71] Aaronson, Prof Sir Michael: *Robots don't kill people, it's the humans we should worry about.* The Conversation 31 May 2013. Accessed at **https://theconversation.com** on 1 July 2013.

[72] **Corporation** *noun*; an entity that has legal personality. Oxford; A Dictionary of Law (7th Edition).

[73] The US Government reportedly paid reparations to Bulgaria after an AGM-88 missile failed to guide onto its intended target in Yugoslavia. See *NATO Missile Goes Astray and Hits House in Bulgarian Capital.* The New York Times (online) 30 April 1999. **http://www.nytimes.com** accessed 6 July 2013.

[74] '*The LEGAD's overriding duty is to provide the commander with timely, accurate, relevant, succinct, legal advice*' UK Joint Doctrine Publication 3-46 *Legal Support to Joint Operations* (Second Edition), 2010. Para 112.

[75] Few land or maritime commanders would understand the detail of how collateral damage estimates are conducted prior to the use of an air-delivered weapon, or how the weapon's guidance system works. Consequently, the advice on whether to use a particular weapon is provided to the commander by his specialist air staff, but having received that advice, and having authorized use of the weapon, the commander is generally responsible for the outcome.

[76] *'For military systems deployed in the field, one possible method is through the use of a responsibility advisor, designed for both run-time and pre-mission aspects of a robotic mission.*' Arkin, Prof R: T*he Robot didn't do it: A position paper for the workshop on anticipatory ethics, responsibility and artificial agents.*

[77] Asaro, P: *'On banning autonomous weapon systems: human rights, automation, and the dehumanization of lethal decision-making.*' International Review of the Red Cross, Volume 94, Number 886, Summer 2012. Lines 824-829.

[78] *Mens rea:* the intention or knowledge of wrongdoing that constitutes part of a crime. Concise Oxford English Dictionary (12th Edition).

[79] '*…the objective of warfare is to achieve and exploit advantages to the enemy's detriment. Sensitive to this reality, the law of armed conflict has never been about ensuring a "fair fight"…*' Schmitt & Thurnher: *'Out of the Loop: Autonomous Weapon Systems and the Law of Armed Conflict".* Harvard College 2013. Page 232.

[80] Attributed to General George S Patton and used in the biographical film *Patton*.

[81] Sun Tzu *The Art of War* (Chapter 6). Published c.500BC.

[82] Cole, C *et al: Convenient Killing – Armed Drones and the Playstation' Mentality.* Fellowship of Reconciliation, September 2010. Page 4.

[83] The unsubstantiated claim has even been reiterated in a *Report on extrajudicial, summary or arbitrary executions* by Special Rapporteur, Philip Alston. Published by the UN General Assembly 28 May 2010. Paragraph 84.

[84] Filkins, D. *Operators of Drones are Faulted in Afghan Deaths.* New York Times. **www.nytimes.com/2010/05/30/world/asia/30drone.html** accessed 15 July 2013.

[85] Ground observers had reported a convoy moving towards an area where US forces were

engaging insurgents and queries whether the convoy contained insurgent reinforcements.

[86] *'Killing someone with an RPA is not different than with an F-15. It's easy to think that [it's like a video game], to fall down that trap. We're well aware that if you push that button somebody can go away. It's not a video game. You take it very seriously. It's by far nowhere near a video game.'* Interview with USAF Major Bryan Callahan. *'Interview with a drone pilot'.* Spiegel Online 12 March 2010. **www.speigel.de/international/world** accessed 16 July 2013.

[87] P W Singer is a Senior Fellow and Director of the 21st Century Defense Initiative at the Brookings Institution in Washington. He has extensively researched the use and development unmanned and autonomous systems.

[88] Singer, P W: *Interview with Defense Expert P W Singer.* Spiegel Online, 12 March 2010. **www.spiegel.de/international/world** accessed 16 July 2013.

[89] *Jus ad bellum criteria:* (1) just cause, (2) comparative justice, (3) legitimate authority, (4) right intention, (5) probability of success, (6) last resort, and (7) proportionality.

[90] But adversaries may seek to respond asymmetrically, and maybe illegally, in such a way that might result in greater loss of life (for example, by perpetrating terrorist atrocities against civilian targets).

[91] O'Connell, Prof. Mary Ellen: *Seductive Drones – Learning from a Decade of Lethal Operations.* Legal Studies Research Paper 11-35 published by Notre Dame Law School, August 2011. p20.

[92] Quintana, Elizabeth. *Unmanned Systems: Confusing Ethics.* A RUSI Analysis Paper dated 20 Apr 2011. Last accessed at **www.rusi.org** on 14 June 2013.

[93] Leveringhaus, Alexander. *Much Ado About Killer Robots*. e-International Relations, 4 June 2013. *('Three Fallacies in the Killer Robots Debate: [No.2] War becomes riskless, never mind the Russian nukes.)* **http://www.e-ir.info/2013/06/04/much-ado-about-killer-robots** accessed 7 July 2013.

[94] 'Collateral Damage' is defined as *'inadvertent casualties and destruction of civilian areas caused by military operations'.* Allied Administrative Publication (AAP 06). Published by NATO, 2013. Page 2-C-6.

[95] *'Just because an engagement is permissible by the law of war and the rules of engagement, it does not always mean that forces should engage…A lack of tactical patience can contribute to civilian casualties (CIVCAS).* International Security Assistance Force (Afghanistan) COIN Advisory Note No. 20100512-001 *Tactical Patience.* Source **http://www.isaf.nato.int** accessed 3 Aug 2103.

[96] For example, using technology such as that in the Tracking Point rifle. See **http://www.popsci.com/technology/article/2013-01/intelligent-rifle-now-ipad-app-wi-fi-infallible-accuracy** accessed 9 Oct 2013.

[97] Singer, P W: *Wired for War* (Penguin 2009) Chapter 10 (p.179) and specifically p.204.

[98] Due to the provisions of the European Convention on Human Rights.