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KILLER ROBOTS:
THE RISKS AND OPPORTUNITIES OF AI IN MILITARY OPERATIONS

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AIM

1. The aim of the service paper is to examine the risks and opportunities of the most transformative technology on the horizon—artificial intelligence (AI) and autonomy—and their effect on the fundamental nature of military operations.

INTRODUCTION

2. Much of what gives Western forces their technological and tactical advantage stems from space-enabled systems, and agile information management and technology tools to aggregate and manipulate large quantities of data. These technological developments point to a future of defence that is expected to be vastly different than today.[1] In particular, the increasing application of artificial intelligence and autonomy to the realm of defence and security is a disruptive force that will significantly affect the future security environment.

3. Intelligent machines have been a part of pop culture for many years. From Czech playwright Karel Čapek's original 1920 play, *R.U.R.*, or *Rossum's Universal Robots*—where the term 'robot' was coined—to the Arnold Schwartzenegger movie The Terminator, the idea of

[1] Canadian Forces College, "DS545 CPT SP Topic List," (Joint Command and Staff Programme 44), 8.

killer robots has been around for almost a century.[2] Lethal autonomous weapon systems (LAWS), however, are no longer the stuff of science fiction. Many types of autonomous weapons already exist—from anti-aircraft systems to self-guided missiles—and advancements in AI continue to spur developments in other applications of autonomous weapon systems.

4. Although military technological advances are nothing new, the introduction of artificial intelligence in defence and security, particularly in the use of lethal force, is a game changer. As Amandeep Gill, the chair of the United Nations' 2017 Group of Governmental Experts on LAWS, pointed out, "[the difference is] the prospect of losing human control, however imperfect and unwise it has been historically, over the waging of war to machines. The weapon, separate thus far in combat, could in fact fuse with the wielder."[3] Taking humans 'out of the loop' from the application of violence will have significant ramifications on the way military operations are conducted. It raises questions of command and control, responsibility and accountability of these autonomous weapons, and forces us to look at political/strategic, force development, legal, and ethical implications of employing and defending against LAWS. At the same time, it provides many opportunities for the Canadian Armed Forces (CAF) to leverage these technologies as a force multiplier.

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[2] United States, NPR, "Science Diction: The Origin Of The Word 'Robot'," 22 April 2011, https://www.npr.org/2011/04/22/135634400/science-diction-the-origin-of-the-word-robot.

[3] Amandeep S. Gill, "Introduction," in "Perspectives on Lethal Autonomous Weapon Systems," *UNODA Occasional Papers*, No. 30, November 2017*:* (New York: United Nations), 1.

DISCUSSION

5. Definitions. First, we begin by defining what an autonomous weapon system is. There is not yet an agreed international standard and many definitions abound, differentiated by the level of the machine's understanding and the level of human supervision, if any. One definition that encapsulates the range of concepts is the United Kingdom's definition:

> 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.[4]

6. Current and Future Trends. Based on the above definition, we can look at some of the existing and emerging technologies in use or in development by the Canadian Armed Forces (CAF) and our Allies.

a. Existing Weapons. In fact, many autonomous weapon systems already exist. Close-in weapon systems (CIWS), such as the Phalanx equipped on the Royal Canadian Navy's *Halifax* class frigates, can identify and engage hostile aircraft within its range automatically.[5] In the air, loitering munitions such as Israel's Harpy, can select and attack

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[4] United Nations Institute for Disarmament Research, "The Weaponization of Increasingly Autonomous Technologies: Concerns, Characteristics and Definitional Approaches," *UNIDIR Resources*, No. 6 (2017), 29.

[5] Naval Technology, "Halifax Class Frigates," accessed 3 February 2018, https://www.naval-technology.com/projects/halifax/.

targets over a designated area and period, using on-board sensors and pre-programmed target signatures.[6] On the ground, the sentry robot SGR-1 is deployed on the border between North and South Korea, and can detect targets up to 3.5 km.[7] Other examples, such as vehicle 'active-protection' weapons, sea mines, and counter-rocket, artillery and mortar systems, demonstrate the wide range of LAWS that are already in use today.

b. Emerging Technology and Future Trends.

(1) Self-Driving Vehicles. Many major car manufacturers, including Tesla, General Motors, Audi, and even Google, have already been testing self-driving cars for several years. With an impressive array of cameras, radars, lasers, etc., these vehicles can achieve situational awareness of their environment and make decisions regarding its speed and direction. More and more self-driving vehicles will no doubt be on the road soon, once legislative and liability issues are overcome.

(2) Drone Swarms. Not only are machines becoming more autonomous, they are also becoming cooperative. Whereas a single machine could malfunction or fail at its task, a group of machines, much like a military unit, can work as a team and mutually support each other in accomplishing its mission, e.g. the U.S. Perdix system.[8]

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[6] International Committee of the Red Cross, *Autonomous Weapon Systems: Implications of Increasing Autonomy in the critical Functions of Weapons*, Expert meeting, Versoix, Switerland, 15-16 March 2016, 75.

[7] Group Captain (retired) Ajey Lele, "A military perspective on lethal in autonomous weapon systems," in "Perspectives on Lethal Autonomous Weapon Systems," *UNODA Occasional Papers*, No. 30 (November 2017): (New York: United Nations), 59.

[8] *Ibid*, 60-61.

(3) Machine Learning. Machine learning enables autonomous systems to find statistical relationships in data. Using neural networks that mimic the human brain, machines are becoming very effective at extracting meaning from massive amounts of data, resulting in advances such as facial recognition and language processing.[9]

7. Risks. It is clear that the obstacle to the continued development of LAWS will not be a technical one. As AI technologies continue to progress, it behooves the Department of National Defence (DND) to stay abreast of these advances and to develop policies, doctrine and training to address the risks of using autonomous weapon systems, by friendly or enemy elements, in the battlespace. These risks include:

a. Political/Strategic. As a transformative technology, AI will undoubtedly have political and strategic impacts in the realm of defence and security. LAWS have the potential to be a game-changing enabler and force multiplier that could tip the balance of international power. As Russian President Vladimir Putin declared, "Artificial intelligence is the future, not only for Russia, but for all humankind. It comes with colossal opportunities but also threats that are difficult to predict. Whoever becomes the leader in this sphere will become ruler of the world."[10]

(1) Proliferation. The transformative nature of LAWS, in conjunction with the low-cost and accessibility of their components, leads to potential for proliferation

[9] International Committee of the Red Cross, *Autonomous Weapon Systems: Implications of Increasing Autonomy in the critical Functions of Weapons*, Expert meeting, Versoix, Switerland, 15-16 March 2016, 38.

[10] RT, "'Whoever leads in AI will rule the world': Putin to Russian children on Knowledge Day," 1 September 2017, https://www.rt.com/news/401731-ai-rule-world-putin/.

to states and non-state actors. At the same time, the search for countermeasures to such weapons will increase, which would accelerate the development of electromagnetic, cyber and information operations to penetrate not only the physical weapon systems, but the command, control and communications networks that provide autonomous systems with information. These trends could result in an arms race of LAWS.[11]

(2) Strategic Stability. As the arms race heats up, states may attempt to gain a first-mover advantage. As weapons become increasingly autonomous and with less concern for force protection, belligerents may be more inclined to resort to the use of force. In addition, automation would enable shorter delays between decision and action. These dynamics may create or aggravate regional or global instabilities and heighten the chances of a "flash war."[12]

b. Force Development. Although most states are developing LAWS from scratch, non-state actors, terrorists and criminals may choose a different development path. As more and more autonomous technologies are becoming accessible, those with fewer resources will likely take a commercially available civilian technology and weaponize it. 9/11 was the classic example of such an approach; and more recent examples include

[11] United Nations Institute for Disarmament Research, "The Weaponization of Increasingly Autonomous Technologies: Concerns, Characteristics and Definitional Approaches," *UNIDIR Resources*, No. 6 (2017), 5.

[12] *Ibid*.

ISIS dropping grenades with drones in Iraq,[13] and numerous terrorist attacks by vehicle across the United States and Europe.[14]

c. If combined with autonomous technologies, these attacks could become even more deadly and difficult to prevent. While law enforcement could shoot a driver to stop a vehicle, or at least arrest him/her and prevent future attacks, it would be more challenging to ascertain who activated a self-driving car that attacked civilians.

d. Legal. International law governing LAWS is still in development. Discussions by government representatives and experts have been ongoing since 2014 under the auspices of the UN's Convention on Certain Conventional Weapons (the same convention that governs anti-personnel mines and biological weapons).[15] As such, current discussions on the use of LAWS revolve around compliance with international humanitarian law (IHL). Some would argue there is an "accountability gap" in the use of LAWS.[16]

(1) State Responsibility. The simplest legal application to LAWS is state responsibility, as a state is clearly liable for any violations of IHL resulting from their armed forces' use of an autonomous system. International law would behoove states to employ LAWS in accordance with IHL and to conduct legal reviews of any new weapons.

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[13] Marc Walker, "ISIS using 'increasingly unconventional' weapons as footage shows drones dropping grenades on army forces," *Mirror*, 27 February 2017, https://www.mirror.co.uk/news/world-news/isis-using-increasingly-unconventional-weapons-9928395.

[14] CNN, "Terrorist Attacks by Vehicle Fast Facts," *CNN*, 3 February 2018, https://www.cnn.com/2017/05/03/world/terrorist-attacks-by-vehicle-fast-facts/index.html.

[15] United Nations Office at Geneva. "Background on Lethal Autonomous Weapon Systems in the CCW," accessed 3 February 2018, https://unog.ch/80256EE600585943/(httpPages)/8FA3C2562A60FF81C1257CE600393DF6?OpenDocument.

[16] International Committee of the Red Cross, *Autonomous Weapon Systems: Implications of Increasing Autonomy in the critical Functions of Weapons*, Expert meeting, Versoix, Switerland, 15-16 March 2016, 17.

(a) Legal Review. Article 36 of the Additional Protocol I to the Geneva Conventions also obligates party states to conduct legal reviews of any new weapons, which would include emerging LAWS. This review must ensure that, once activated, the LAWS would predictably and reliably operate as intended. But such a verification is especially challenging for AI systems, as standard methods and protocols have yet to be developed. In addition, their self-learning capability means they would react differently with experience over time; hence it is difficult to predict how it may react in a given scenario.

(2) Individual Responsibility. With regards to the use of LAWS, it becomes difficult to attribute an individual's—either the commander or the operator—responsibility for a war crime or violation of IHL. The International Criminal Court requires that direct intent (*mens rea*) be established in order to determine criminal liability. As automation allows the LAWS to select and engage targets independently to some extent, it could be difficult to prove that the human knew with certainty that such a violation would occur.[17]

(3) Programmer Responsibility. Lastly, the programmer could potentially be responsible for the actions of the machine, as it is s/he who developed the algorithm that determines the LAWS's action. This liability has similar issues to the above, where it is difficult to prove intent. Nevertheless, programmers, and their parent companies, can be found negligent. For example, in the case of the first fatality in a self-driving car in May 2016, the American National

[17] *Ibid*.

Transportation Safety Board found Tesla to be partially responsible for Joshua Brown's death, despite the disclaimer that its Autopilot feature still requires human supervision, and numerous warnings before the crash that were ignored by the driver.[18]

e. Ethical. Finally, the key problem to the use of LAWS by most states and international organizations is an ethical one: can we entrust the uniquely (and sadly) human endeavour of war to machines, and if so, how do we ensure that LAWS will abide by ethics and international humanitarian law?

(1) The Human Before the Robot. At the end of the day, it is important to remember that robots, even autonomous ones, are tools developed and deployed by humans to achieve a specific goal. Although it is easy to be seized by the incredible advancements in technology that enable LAWS to become more and more formidable, we must not be caught on our heels and merely react to these rapid technological changes. Instead, the autonomy question is "really about what control or oversight we expect humans to maintain over the tools of violence that we employ."[19] Focussing on the human aspect of this issue will allow us to use a common language and remain consistent with international humanitarian law, as well as being prepared to tackle similar questions with as-yet unimagined technological developments that may be weaponized in the future.[20]

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[18] Aarian Marshall, "Tesla bears some blame for self-driving crash death, Feds say," *Wired*, 13 September 2017, https://www.wired.com/story/tesla-ntsb-autopilot-crash-death/.

[19] Ms Kerstin Vignard, "Addressing the challenges raised by increased autonomy," in International Committee of the Red Cross, *Autonomous Weapon Systems: Implications of Increasing Autonomy in the critical Functions of Weapons*, Expert meeting, Versoix, Switerland, 15-16 March 2016, 67.

[20] *Ibid*, 68.

(2) The Decision to Kill. The critical issue bearing on IHL compliance is not whether LAWS 'selects and engages' without human intervention, but rather, as Lt Col. Alan Schuller from the US Naval War College highlights, "whether [the machine] has been granted some critical combination of functions that effectively delegate the *decision to kill* from human to machine."[21] Regardless of the extent to which machines are involved in the intelligence, targeting and engagement processes—and they can be extremely useful in all of these areas—a human, the commander, ultimately decides the parameters the machine is given in its mission. It is only the human who can apply understanding and judgment to decide who to kill or what to destroy, while staying within the bounds of distinction, proportionality, military necessity, and unnecessary suffering.

8. Opportunities. Despite these risks, automation offers many opportunities for the CAF to enhance its capabilities and protect its forces. Investments in existing and emerging AI technologies in some or all of the following areas would better prepare the CAF for the automated battlespace of tomorrow:

a. Force Projection. As General Vance has stated on the topic of armed drones, "I think it's important for a military force to have a range of options available to it. In my view, there's no point in having a UAV [unmanned aerial vehicle] that can see a danger

[21] Lt Col. Alan Schuller, "Focusing the debate on autonomous weapon systems: A new approach to linking technology and IHL," in International Committee of the Red Cross, *Autonomous Weapon Systems: Implications of Increasing Autonomy in the critical Functions of Weapons*, Expert meeting, Versoix, Switerland, 15-16 March 2016, 26.

but can't strike, if it needs to."[22] An autonomous drone can extend that reach even further, enabling a commander or operator to strike even when time or distance precludes direct control of the asset.

b. Force Multiplication. LAWS are a force multiplier that will allow fewer soldiers to do the same job as before. Routine tasks such as surveillance and sentry duty, as well as complex ones like intelligence analysis and targeting, can be supported by the speed and persistence of artificial intelligence. AI with a target database and facial recognition can indefatigably monitor information from multiple sensors to detect and alert operators to targets, or even engage them autonomously.

c. Force Protection. The employment of LAWS could allow removing soldiers from some of the most dangerous and life-threatening missions. The Royal Canadian Engineers, for instance, already employ explosive ordinance disposal robots. Automation of these robots could enable the automated sweeping of improvised explosive devices (IED) from, say, a main supply route.

d. Responsiveness. Just as CIWS provides a quicker than human response to hostile aircrafts and missiles, LAWS can be applied to other domains, especially the land environment. As they can integrate more information from more sources much faster than a human, they could be used to protect CAF personnel and assets from fast-moving or massed threats; for example, defending a forward operating base from incoming rockets or armed drones.

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[22] Murray Brewster, "Gen. Vance wants drones with strike capability," *CTV News*, 7 March 2016, https://www.ctvnews.ca/canada/gen-vance-wants-drones-with-strike-capability-1.2807493.

e. Logistics. LAWS could also be employed to support logistics. On 20 October 2016, Otto and Budweiser completed the world's first shipment by self-driving truck, delivering 50,000 cans of beer over 200 kilometres (120 miles), from Fort Collins to Colorado Springs, Colorado,[23] signalling a disruptive change in the transportation industry. In the military context, vulnerable supply convoys could be replaced by autonomous vehicles that could navigate, detect and defend themselves from threats such as IEDs and rocket propelled grenades, removing soldiers from one of the most dangerous tasks in a stability or counter insurgency operation.

f. Ethical Robots. Research into ethical autonomy could potentially produce robots that can adhere to the existing laws of war as well as or better than soldiers. For example, LAWS can act more conservatively in uncertain situations, such as the approach of an unidentified vehicle to a camp, as they do not have a drive for self-preservation and could even self-sacrifice if needed.[24]

g. Ethical Governors. Robots can also be programmed with international humanitarian law and the rules of engagement. When combined with a team of human soldiers, LAWS could potentially be used to monitor ethical behaviour in the battlespace by all parties independently and objectively. This presence may reduce the incidence of human ethical infractions in times of conflict and heightened emotions.[25]

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[23] "Otto and Budweiser: First Shipment by Self-Driving Truck," YouTube video, 2:33, posted by "Uber Advanced Technologies Group," 25 October 2016, https://www.youtube.com/watch?v=Qb0Kzb3haK8.

[24] Ronald C. Arkin, "A robotocist's perspective on lethal autonomous weapon systems," in "Perspectives on Lethal Autonomous Weapon Systems," *UNODA Occasional Papers, No. 30*, November 2017*:* (New York: United Nations), 39.

[25] *Ibid*, 40-41.

CONCLUSION

9. Lethal autonomous weapon systems are here and will only proliferate over time. The CAF must prepare for this new transformative technology immediately, as it is a complex issue that is arriving quickly on our doorstep. As Izumi Nakamitsu, the United Nations' Under-Secretatry General High Representative for Disarmament Affairs, affirms,

> … LAWS could seriously test existing legal frameworks by posing novel challenges for attribution and accountability. They also pose ethical and moral quandaries …. The disturbing propects are not only concerning, but urgently so. This is because there is today no technical barrier to the deployment of LAWs.[26]

RECOMMENDATIONS

10. In conjunction with Global Affairs Canada, DND should advise and assist the UN and international organizations' efforts to establish an international law on the development and proliferation of lethal autonomous weapon systems.

11. DND should invest in existing and emerging autonomous technologies that would ensure the CAF's ability to operate in the AI-dominated security environment of the future. It should also develop the capability to verify and test the predictability and reliability of autonomous weapon systems.

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[26] Izumi Nakamitsu, "Foreword," in "Perspectives on Lethal Autonomous Weapon Systems," *UNODA Occasional Papers, No. 30*, November 2017*:* (New York: United Nations), v.

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