Autonomous Doctrine: Operationalizing the Law of Armed Conflict in the Employment of Lethal Autonomous Weapons Systems

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ARTICLE

AUTONOMOUS DOCTRINE: OPERATIONALIZING THE LAW OF ARMED CONFLICT IN THE EMPLOYMENT OF LETHAL AUTONOMOUS WEAPONS SYSTEMS

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I. INTRODUCTION

The world has become thoroughly familiar with the concept of robotic systems that can operate without human control. In science fiction, these have ranged from helpful computers or robotic servants[1] to emotionless, unstoppable killing machines.[2] However, autonomous machines—those that can function with minimal or no human oversight—have become an almost ubiquitous reality. Machines manage stock trades,[3] drive cars,[4] and are increasingly contemplated as a means and method of warfare.[5] The popular perception of future lethal autonomous weapons (LAWS) as unrestrained killers has spawned both negative public perception and calls for partial or outright bans on these "killer robots."[6] Contrary to the contentions of ban proponents, LAWS can be effectively employed in appropriate circumstances, in compliance with the Law of Armed Conflict

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1. For example, the STAR WARS (Lucasfilm 1977) characters C-3PO or R2-D2.

2. *See* TERMINATOR 2: JUDGMENT DAY (Carolco 1991) (chronicling a high stakes chase to evade an indestructible robot made of liquid metal aiming to thwart an attempt to save the world from robotic control); *see also* Daniel Cebul, *Former Google Exec: AI Movie Death Scenarios 'One to Two Decades Away'*, DEFENSE NEWS (Feb. 28, 2018), https://www.defensenews.com/smr/munich-security-forum/2018/02/28/former-google-exec-ai-movie-death-scenarios-one-to-two-decades-away/ [https://perma.cc/7J6N-3R5U] (explaining despite the pendency of AI, it will not dispense with human control for critical decision-making).

3. *See generally* Andrei Kirilenko et al., *The Flash Crash: The Impact of High Frequency Trading on an Electronic Market*, 72 J. FIN. 967 (2017) (detailing the impact of automated trading algorithms on the May 6, 2010, "flash crash" in the U.S. stock market).

4. For example, Google's self-driving car concept, now known as Waymo. WAYMO, https://www.google.com/selfdrivingcar/ (last visited July 23, 2019) [https://perma.cc/5E3E-5J8Y].

5. *See, e.g.*, HEATHER M. ROFF, MEANINGFUL HUMAN CONTROL OR APPROPRIATE HUMAN JUDGMENT? THE NECESSARY LIMITS ON AUTONOMOUS WEAPONS 5–6 (Ariz. St. Univ. Global Security Initiative briefing paper for Conference of the Convention on Certain Conventional Weapons, 2016) (contemplating the balance between autonomy and human control in the robotic weapon systems).

6. *See, e.g.*, HUMAN RIGHTS WATCH, LOSING HUMANITY: THE CASE AGAINST KILLER ROBOTS 2 (2012) ("Our research and analysis strongly conclude that fully autonomous weapons should be banned and that governments should urgently pursue that end.").

(LOAC) by implementing a series of control mechanisms and tactics, techniques, and procedures (TTPs) that are either already in use by the U.S. military, or can be readily adapted to the context of autonomous weapons systems.

Proponents advocating for a full ban on LAWS make categorical statements contending, "robots with complete autonomy would be incapable of meeting [LOAC] standards," and that LAWS would necessarily "strip civilians of protections from the effects of war that are guaranteed under the law."[7] Others argue that LAWS violate the LOAC principle of "humanity" in war, which requires human characteristics and compassion.[8] Ban proponents deem that "killing at a remove" strips the human aspect from war, making it cold, impersonal, and therefore, inherently indiscriminate.[9] These arguments are based around a belief that war and violence are fundamental human endeavors, and that only a compassionate human being can ethically and morally make the decision to use lethal force.[10] This failure of "humanity" in LAWS, many argue, brings such weapons within the ambit of the Martens Clause, which prohibits the means or methods of warfare that diverge from the "principles of international law derived from established custom, from the principles of humanity and from the dictates of public conscience."[11] Many proponents of a preemptive ban also employ incomplete factual assertions to bolster their arguments.

One example of such reasoning is to argue in broad terms that machines are, and will always be, incapable of distinguishing between civilians and

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7. *Id.* at 3, 30.

8. HUMAN RIGHTS WATCH, ADVANCING THE DEBATE ON KILLER ROBOTS: 12 KEY ARGUMENTS FOR A PREEMPTIVE BAN ON FULLY AUTONOMOUS WEAPONS 15 (2014).

9. *See, e.g.*, HUMAN RIGHTS WATCH, *supra* note 6, at 40 ("the proliferation of unmanned systems, which . . . has a 'profound effect on the "impersonalization of battle,"' may remove some of the instinctual objections to killing.").

10. *See, e.g.*, Holy See, *Elements Supporting the Prohibition of Lethal Autonomous Weapons Systems* 3–4 (U.N. Convention on Certain Conventional Weapons, 2016 Meeting of Experts on LAWS, Working Paper, Apr. 7, 2016), https://www.unog.ch/80256EDD006B8954/(httpAssets)/752E16C02C9AEC E4C1257F8F0040D05A/$file/2016_LAWSMX_CountryPaper_Holy+See.pdf [https://perma.cc/ DYK5-C4G7] (discussing how LAWS can undermine foundations for peace—the mutual trust between nations).

11. Protocol Additional to the Geneva Conventions of 12 August 1949, and Relating to the Protection of Victims of International Armed Conflicts (Protocol I), of 8 June 1977, art. 1(2), *opened for signature* Dec. 12, 1977, 1125 U.N.T.S. 3 [hereinafter AP I]; HUMAN RIGHTS WATCH, *supra* note 6, at 24 (arguing the Martens Clause should apply as a means to prohibit LAWS). While the United States is not a state party to AP I, and therefore not bound by its terms, it does consider much of AP I to reflect customary international law. R. Craig Burton, *Recent Issues with the Use of MatchKing Bullets and White Phosphorous Weapons in Iraq*, ARMY LAW, Aug. 2006, at 19 n.4 (Aug. 2006).

combatants, or of assessing intent (e.g., differentiating between a "fearful civilian" and a "threatening enemy combatant").[12] This line of thinking assumes that because machines were incapable of making such assessments as of 2012, that this will always be the case; however, developments over the last several years in the ability of machines to assess emotion contradict that assertion.[13] Furthermore, ban proponents discuss the complexity of warfare in an urban environment, citing to the recent counter-insurgency, or urban combat operations in Iraq and Afghanistan, arguing that machines would be incapable of distinguishing between combatants and civilians or non-combatants as required under the LOAC.[14] In light of this complexity, if a machine is incapable of balancing military necessity against the danger of collateral damage, it may fail to apply a concept known as proportionality to determine whether an attack is justified.[15] This flawed reasoning is twofold. First, counterinsurgency or urban warfare is one of the most complex combat environments, but it is not the only possible environment. Secondly, questions about the application of the LOAC concern rules and decision-making processes, as well as results. Reasonable mistakes which lead to undesired results are not necessarily criminal or unlawful. These are complicated situations and humans often miscalculate questions of distinction and proportionality, mistakenly injuring or killing civilians or other non-combatants as a result.[16] These logical flaws fail to account for the rapid progression of modern machines' capabilities to perceive and process their environment.

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12. Such as differentiating between a "fearful civilian and a threatening enemy combatant." HUMAN RIGHTS WATCH, *supra* note 6, at 4.

13. Sophie Kleber, *3 Ways AI is Getting More Emotional*, HARV. BUS. REV. (July 31, 2018), https://hbr.org/2018/07/3-ways-ai-is-getting-more-emotional [https://perma.cc/3EMV-QVGV].

14. HUMAN RIGHTS WATCH, *supra* note 6, at 30–31.

15. *See* U.S. DEP'T OF DEF., LAW OF WAR MANUAL §§ 2.4–2.5 (2016) for a discussion of the concepts of distinction and proportionality. *See also* HUMAN RIGHTS WATCH, *supra* note 6, at 3–4 ("The rules of distinction, proportionality, and military necessity are also important tools for protecting civilians from the effects of war, and fully autonomous weapons would not be able to abide by those rules.").

16. *See, e.g.*, Press Release, U.S. Cent. Command, U.S. Central Command Releases U.S. Forces: Afghanistan Investigation into Airstrike on Doctors Without Borders Trauma Center in Kunduz, Afghanistan (Apr. 29, 2016), https://www.centcom.mil/MEDIA/PRESS-RELEASES/Press-Release-View/Article/904574/april-29-centcom-releases-investigation-into-airstrike-on-doctors-without-borde/ [https://perma.cc/Y7U9-6B6J] (describing the October 3, 2015 airstrike on a Doctors Without Borders facility that resulted in at least 42 deaths and 229 other injuries as an egregious mistake of distinction attributable to human error).

This article will describe the ways in which many TTPs and concepts currently in use by the U.S. and allied militaries can be readily applied to LAWS. Part II of this article will discuss the current state of development of LAWS, including examples of some of the various LAWS and other autonomous capabilities currently being fielded and developed. Part III will discuss legal challenges and objections to the employment of such systems. Finally, Part IV will provide a more detailed description of (1) developments in autonomous systems that demonstrate the premature concerns and misunderstandings of ban proponents, and (2) a number of precautionary TTPs broken down into mission design controls, capability design controls, and "cognitive" design controls. Comprehensive application of these controls can mitigate legal concerns with LAWS and ensure their employment in accordance with the LOAC.

II.   THE CURRENT STATE OF AUTONOMOUS WEAPONS SYSTEM DEVELOPMENT

Despite contentions from non-governmental organizations (NGOs), like Human Rights Watch and the International Committee of the Red Cross (ICRC), countries continue to press ahead with the development of autonomous systems, including systems that are capable of employing lethal force. Prior to discussing the proper employment of LAWS, it is necessary to define the term. For its part, the United States Department of Defense defines autonomous weapons as those that "once activated, can select and engage targets without further intervention by a human operator. This includes human-supervised autonomous weapon systems that are designed to allow human operators to override operation of the weapon system, but can select and engage targets without further human input after activation."[17] The ICRC defines autonomous weapons as those that can exercise the critical functions of selecting and attacking targets without human intervention.[18] While there is some disagreement at the margins, the critical pieces of any definition appears to be the ability to select and engage targets without human intervention. With that baseline definition in

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17.   U.S. DEP'T OF DEF., DIRECTIVE NO. 3000.09, AUTONOMY IN WEAPON SYSTEMS 13–14 (2012).

18.   Int'l Comm. of the Red Cross Conference on Int'l Humanitarian Law, *Report on International Human Law and the Challenges of Contemporary Armed Conflicts*, at 44, ICRC Doc. 31IC/15/11 (Oct. 2015) [hereinafter ICRC 2015 Report].

mind, there are a number of autonomous capabilities in various stages of development.

The United States military is developing both aerial and maritime (surface and subsurface) unmanned autonomous systems for a variety of roles. The U.S. Department of Defense (DOD) has worked in partnership with the Massachusetts Institute of Technology (MIT) to develop autonomous air-launched systems with swarming capabilities.[19] This swarming capability envisions the use of small, expendable "kamikaze drones" that are essentially small Unmanned Aerial Systems (UAS) with an integrated warhead and sensor array, that could fly into identified hostile targets and explode.[20] Defense conglomerate Lockheed Martin is also pursuing advances in manned-unmanned teaming.[21] Other UAS developments include potential combat unmanned aerial vehicles (UAVs)[22] that are capable of launching and recovering from U.S. Navy aircraft carriers.[23] The Defense Advanced Research Projects Agency (DARPA) has also worked to develop maritime unmanned surface vehicles that would perform submarine tracking missions for up to ninety days of fully autonomous operation.[24] The development of these surface vehicles has also spawned a pair of

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19. Michael Hardy, *Pentagon Proves Air-Launched UAV Swarm Ability*, C4ISRNET (Mar. 15, 2016), http://www.c4isrnet.com/story/military-tech/uas/2016/03/15/pentagon-proves-uav-swarm-ability/81803256/ [https://perma.cc/KC5Z-NBX6].

20. James Drew, *USAF's Small UAS Roadmap Calls for Swarming 'Kamikaze' Drones*, FLIGHTGLOBAL (May 4, 2016), https://www.flightglobal.com/news/articles/usafs-small-uas-roadmap-calls-for-swarming-kamikaz-424973/ [https://perma.cc/5U9L-W8C7].

21. Yasmin Tadjdeh, *Lockheed Martin Investing in Autonomy, Manned-Unmanned Teaming Technology*, NDIA BUS. & TECH. MAG. (Mar. 15, 2016), http://www.nationaldefensemagazine.org/articles/2016/3/15/lockheed-martin-investing-in-autonomy-mannedunmanned-teaming-technology [https://perma.cc/8LKK-VRYV].

22. Patrick Tucker, *Report: Weapons AI Increasingly Replacing, Not Augmenting, Human Decision Making*, DEFENSE ONE (Sept. 2, 2016), http://www.defenseone.com/technology/2016/09/report-weapons-ai-increasingly-replacing-not-augmenting-human-decision-making/131826/ [https://perma.cc/X7E7-LCEU].

23. Brandon Vinson, *X-47B Makes First Arrested Landing at Sea*, USS GEORGE H. W. BUSH PUB. AFFAIRS (July 10, 2013), http://www.navy.mil/submit/display.asp?story_id=75298 [https://perma.cc/X7E7-LCEU].

24. Franz-Stefan Gady, *US Navy Is Speed Testing Sub-Hunting Robot Ship*, THE DIPLOMAT (Apr. 5, 2016), http://thediplomat.com/2016/04/us-navy-is-speed-testing-sub-hunting-robot-ship/ [https://perma.cc/59Y7-CWTS]; Christina Beck, *Check Out Sea Hunter, the US Navy's New 'Crewless Ship'*, THE CHRISTIAN SCI. MONITOR (May 3, 2016), http://www.csmonitor.com/Technology/2016/0503/Check-out-Sea-Hunter-the-US-Navy-s-new-crewless-ship [https://perma.cc/DJD5-4CW7].

unmanned subsurface vehicles[25] that could perform a range of missions including detection, classification, and neutralization of naval mines.[26] The United States is not the only nation developing such weapons.

In 2016, French developer Dassault Aviation's nEUROn long endurance Intelligence, Surveillance and Reconnaissance (ISR) UAV[27] was considered one of the "most advanced" weapon systems in development.[28] Not to be left out in the cold alone by its historic French rival, the United Kingdom, through British Aerospace, is also developing an autonomous UAV, the Taranis.[29] France and the United Kingdom are jointly developing an autonomous maritime mine countermeasure capability, that will operate as part of a network of manned and unmanned surface and subsurface vessels.[30] Other countries are also developing, or have fielded, weapons with varying degrees of autonomy. For example, South Korea's Sentry Guard Robot-1 (SGR-1) guards the Korean Demilitarized Zone (DMZ),[31] while Israel boasts an expendable "kamikaze" UAV Harpy/Harop[32] and the underwater anti-mine "Seagull," contemplated for both anti-submarine and anti-diver/personnel roles.[33] The rapid pace of development for nation states compared to the slow pace in the development of any treaty regulating or banning LAWS over the past four years has generated consternation on the part of ban proponents. The national and diplomatic will to ban weapons that are so tactically appealing and increasingly widespread appears

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25. Michael Peck, *Navy Awards Unmanned Wave Glider Contract*, C4ISRNET (May 4, 2016), http://www.c4isrnet.com/story/military-tech/uas/2016/05/04/navy-awards-uuv-wave-glider-liquid-robotics/83923664/ [https://perma.cc/W7M8-LVH4].

26. Michael Peck, *Knifefish Passes Mine-Hunting Test*, C4ISRNET (Mar. 28, 2017), https://www.c4isrnet.com/unmanned/uas/2017/03/28/knifefish-passes-mine-hunting-test/ [https://perma.cc/Q6AE-MDM5].

27. *nEUROn Unmanned Combat Air Vehicle (UCAV) Demonstrator*, AIR FORCE TECH., https://www.airforce-technology.com/projects/neuron/ [https://perma.cc/RF8V-FEW6].

28. Tucker, *supra* note 22.

29. *Id.*

30. Michael Peck, *Britain and France Move Forward on Mineclearing Drone*, C4ISRNET (Nov. 8, 2016), https://www.c4isrnet.com/unmanned/uas/2016/11/08/britain-and-france-move-forward-on-mineclearing-drone/ [https://perma.cc/LWV6-T2XS].

31. Jean Kumagai, *A Robotic Sentry for Korea's Demilitarized Zone*, IEEE SPECTRUM (Mar. 1, 2007), http://spectrum.ieee.org/robotics/military-robots/a-robotic-sentry-for-koreas-demilitarized-zone [https://perma.cc/3VXC-P29S].

32. Rebecca Crootof, *The Killer Robots are Here: Legal and Policy Implications*, 36 CARDOZO L. REV. 1837, 1871, 1874 (2015).

33. Barbara Opall-Rome, *Elbit Offers Multimission, Unmanned Naval Robot*, DEFENSE NEWS (Mar. 28, 2017), https://www.defensenews.com/smr/unmanned-unleashed/2017/03/28/elbit-offers-multimission-unmanned-naval-robot/ [https://perma.cc/GBT9-CDRS].

to be faltering.[34]   Non-military actors have also pursued autonomous systems such as COTSbot developed by the Queensland University of Technology in Australia.[35]   The COTSbot is designed to autonomously hunt and destroy the invasive Crown of Thorns Starfish (COTS) that is decimating the Great Barrier Reef.[36]

The capabilities of various machines have also improved beyond those thought possible just a few years ago.   The proliferation of artificial intelligence, including concepts such as machine learning and "deep learning" into internet algorithms, social media platforms, and electronic commerce, shows the leaps made over the past several years in machines' abilities to "learn."[37]   This "learning" includes the ability to move beyond simple pattern recognition to "representational learning" where machines ingest raw data and discover common features or aspects of a data set to allow the machine to accurately classify or categorize items in that data set.[38] In contrast to the assertions of Human Rights Watch and other ban proponents that machines will always be incapable of assessing emotion and intent, there have been recent advances in the "sensory" ability of machines to apply certain "sensory," or physiological inputs, data, or object recognition algorithms to identify human emotions.

Machines have already shown a developmental ability to recognize human stress without physical contact by using digital cameras and facial pattern recognition.[39]   Similar capabilities have also been used to apply pattern recognition to human behaviors to identify mental states such as happiness

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34.   Paul Sharre, *We're Losing Our Chance to Regulate Killer Robots*, DEF. ONE (Nov. 14, 2017), http://www.defenseone.com/ideas/2017/11/were-losing-our-chance-regulate-killer-robots/ 142517/ [https://perma.cc/G7JH-7G7E].

35.   *New Robot has Crown-of-Thorns Starfish in its Sights*, QUEENSL. UNIV. OF TECH. NEWS (Sept. 2, 2015), https://www.qut.edu.au/news/news?news-id=95438 [https://perma.cc/HRR2-4HZY].

36.   *Id.*

37.   Yann LeCun et al., *Deep Learning*, 521 NATURE 436, 436 (2015).

38.   DUSTIN A. LEWIS ET AL., WAR-ALGORITHM ACCOUNTABILITY 19 (2016). Deep learning uses the concept of "neural networks" to mimic the functionality of the human brain. *Id.* AlphaGo employed a combination of human supervision and learning through self-play, allowing a machine to beat a human player at the Chinese strategy game Go some ten years earlier than expected. *Id.* at 20; Cade Metz, *In Two Moves, AlphaGo and Lee Sedol Redefined the Future*, WIRED MAG. (Mar. 16, 2016), https://www.wired.com/2016/03/two-moves-alphago-lee-sedol-redefined-future/   [https://perma. cc/3SPV-R38K].

39.   DANIEL J. MACDUFF ET AL., COGCAM: CONTACT-FREE MEASUREMENT OF COGNITIVE STRESS DURING COMPUTER TASKS WITH A DIGITAL CAMERA, *in* PROCEEDINGS FOR THE COMPUTER AND HUMAN INTERACTION CONFERENCE 4000, 4000–03 (2016).

and depression.[40] MIT has developed a system that uses wireless radio frequency signals to measure, at a distance, a person's heart rate. It then applies machine learning and an "emotion classifier" to identify a person's mood without physical contact.[41] Perhaps most astonishing, Professor Jack Gallant and his associates have shown the ability to digitally reconstruct what a person is seeing by measuring brain activity with magnetic resonance imaging (MRI) technology.[42] With a combination of MRI technology, a sufficient baseline data set for comparison, and algorithms designed to sense, assess, and characterize various physiological inputs, and other technologies, it is not outside the realm of possibility that machines could in fact sense human emotions. While LAWS that could sense and interpret human emotions would certainly assuage concerns about a machine's ability to account for human intent, this is not a prerequisite for their lawful employment. Rather, by examining the relevant legal challenges, it is possible to craft a series of control measures that can be readily adopted and employed to ensure that LAWS are used in compliance with international law. By employing a suitable algorithm, paired with and effectuated through a suitably constructed system,[43] it is possible to craft a series of precautionary employment TTPs to ensure that LAWS could be employed in accordance with the LOAC.

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40.   Natasha Jaques et al., *Predicting Student's Happiness from Physiology, Phone, Mobility, and Behavioral Data*, MIT (2017), https://dspace.mit.edu/bitstream/handle/1721.1/107917/Picard_Predicting%20 students.pdf?sequence=1&isAllowed=y [https://perma.cc/7KBA-N654].

41.   Charles Q. Choi, *Mood-Detecting Sensors Could Help Machines Respond to Emotions*, IEEE SPECTRUM (Sep. 20, 2016), https://spectrum.ieee.org/the-human-os/robotics/robotics-hardware/mooddetecting-sensor-could-help-machines-respond-to-emotions   [https://perma.cc/ 5RY5-THNL].

42.   *See generally* Shinji Nishimoto et al., *Reconstructing Visual Experiences from Brain Activity Evoked by Natural Movies*, 21 CURRENT BIOLOGY 1641(presenting a new motion-energy encoding model to overcome the limitations in MRI brain activity measurements). Part of the research team's conclusion is that dynamic brain activity, not only visual experiences, can be decoded using MRI technology. *Id.* at 1641, 1645. While the ability to monitor brain activity currently requires contact with the subject's head, it may be possible in the future for such brain activity to be "read" remotely from a distance.

43.   Harvard's Program on International Law and Armed Conflict (PILAC) poses that there are "two key ingredients" required for a machine to "make and effectuate a decision": an algorithm, paired with "a suitably capable constructed system." LEWIS ET AL., *supra* note 38, at 15–18.

III. LEGAL FRAMEWORK FOR EMPLOYMENT OF
LETHAL AUTONOMOUS WEAPONS SYSTEMS

A. *LOAC: The Four Principles, and Challenges Presented by LAWS*

As a foundational matter, there are four core concepts of the LOAC, and employment of any weapon system (autonomous or otherwise) must comply with those requirements in order to be lawful. These concepts are (1) military necessity, (2) distinction, (3) proportionality, and (4) humanity or the limitation of unnecessary suffering. Military necessity, distinction, and the related concept of proportionality are really where the difficulty lies with regard to the employment of LAWS. The concept of humanity or unnecessary suffering does not appear to pose an issue so long as LAWS employ lethal or kinetic means in accordance with their expected use.[44] Blanket statements regarding distinction, proportionality, and military necessity, such as "robots with complete autonomy would be incapable of meeting international humanitarian law standards,"[45] have led to calls to ban autonomous weapons as part of the United Nation's Convention on Certain Conventional Weapons (CCW) treaty process.[46] However, such statements do not account for other possibilities, such as the employment of TTPs to mitigate such capability gaps. Such TTPs could be used as precautions in the employment of LAWS to ensure their use is in accordance with the LOAC.[47] Before proposing solutions, it is necessary to identify the legal and practical challenges of employing LAWS.

The first concept, military necessity, is the principle that "justifies the use of all measures needed to defeat the enemy as quickly and efficiently as possible that are not prohibited by the law of war."[48] Pursuant to the concept of military necessity, those objects, materiel, or personnel which by their nature, purpose, location, or use make an effective contribution to thwarting enemy military action, may be made the object of an attack.[49] The related concept is the obligation to distinguish between military objectives and civilian objects. This is known as "distinction," and is in

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44. Jeffrey S. Thurnher, *No One at the Controls: Legal Implications of Fully Autonomous Targeting*, 67 JOINT FORCES Q. 77, 80–82 (2012).

45. HUMAN RIGHTS WATCH, *supra* note 6, at 3.

46. ICRC 2015 Report, *supra* note 18, at 44.

47. AP I, *supra* note 11, at art. 57.

48. U.S. DEP'T OF DEF., *supra* note 15, at § 2.2.

49. Thurnher, *supra* note 44, at 80; Michael N. Schmitt, *Military Necessity and Humanity in International Humanitarian Law: Preserving the Delicate Balance*, 50 VA. J. INT'L L. 795, 802–05 (2010).

essence the capability to "aim" the weapon. In the context of LAWS, it would refer to the reliability of the weapon making the "right" choice in a relatively familiar, and well-understood environment, and the predictability of the weapon making the "right" choice in unfamiliar or unforeseen circumstances.

This concept of distinction requires an attacker to distinguish between legitimate military targets, and civilians or civilian objects.[50] Ban proponents have honed in on the most challenging warfighting scenario, counterinsurgency in urban terrain, in the effort to demonstrate the inability of LAWS to comply with the LOAC.[51] Based on advances in the abilities of machines to sense their environment, and the potential to assess human emotions, this may not hold entirely true in the future.[52] Regardless, the law of war recognizes the obligation to "take feasible precautions in planning and conducting attacks to reduce the risk of harm to civilians" and other protected objects.[53] Such precautions in the attack may include assessing the risk to civilians, identifying zones in which civilians are unlikely to be present, adjusting the time of the attack to a time when civilians are less likely to be present, and thoroughly considering employment of weapons and weapon systems.[54]

Through the application of precautionary TTPs based on capabilities and circumstances, it is entirely possible to employ increasingly capable machines in compliance with the LOAC. The more accurately machines are able to identify physiological and behavioral indicators of physical ability, emotion, or intent, and the more predictably and reliably they can interpret those indicators in both familiar and unfamiliar scenarios, then it is not unforeseeable that autonomous systems may be able to more accurately identify intent or emotion than a human being dealing with the stressors of

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50. *E.g.*, AP I, *supra* note 11, at arts. 48, 51(4).

51. HUMAN RIGHTS WATCH, *supra* note 6, at 13. Human Rights Watch argues that a machine could not tell the difference between a wounded or faking enemy. However, this is not a problem unique to machines. *See, e.g.*, Kevin Sites et al., *U.S. Probes Shooting at Fallujah Mosque: Video Shows Marine Killing Wounded Iraqi*, MSNBC.COM & NBC NEWS (Nov. 16 2004), http://www.nbcnews.com/id/6496898/ns/world_news-mideast_n_africa/t/us-probes-shooting-fallujah-mosque/#.VzOLPjZf17g [https://perma.cc/C2WT-GFUD] (detailing events during the Battle of Fallujah where a Marine shot a wounded Iraqi fighter, claiming that the Iraqi was faking his wounds).

52. MACDUFF ET AL., *supra* note 39, at 4000–03; Jaques et al., *supra* note 40.

53. *See* U.S. DEP'T OF DEF., *supra* note 15, at § 5.11 (quoting Letter from Harold Koh, Legal Adviser, U.S. Dep't of State, to Paul Seger, Legal Adviser of Switz. (Dec. 30, 2009) (characterizing AP I, Article 57(4) as "an accurate statement of the fundamental law of war principle of distinction.").

54. *Id.* § 5.11.6 n.372.

combat. In combination with all other factors, this may contribute to machines being better able to positively identify lawful targets than humans in certain circumstances. Furthermore, this question of distinction is most complicated when dealing with individual human targets. The situation can be simplified if the LAWS employ sensors such as radar identification,[55] or sensors that can distinguish between enemy armored vehicles and other types of civilian vehicles.[56]

Lastly is the thorny question of proportionality. As typically formulated, the rule of proportionality requires a commander to weigh whether an attack may cause civilian casualties that are disproportionate to the military advantage to be gained.[57] "In determining whether an attack was proportionate[,] it is necessary to examine whether a reasonably well-informed person in the circumstances of the actual perpetrator, making reasonable use of the information available to him or her, could have expected excessive civilian casualties to result from the attack."[58] While this rule is relatively easy to articulate, in practice, it is much more difficult to apply.[59] This question of proportionality becomes increasingly difficult in light of changing circumstances and dynamic combat environments.[60]

The International Committee of the Red Cross has expressed "serious doubts about the capability of developing and using autonomous weapons systems that would comply with [the LOAC] in all but the narrowest of scenarios and the simplest of environments."[61] However, not only machines struggle with this assessment, as it is incredibly difficult and complex for human beings, as well.[62] Despite, or perhaps because of its

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55. *See, e.g.*, Harpy NG: Anti-Radiation Loitering Weapon System, ISR. AEROSPACE INDUS. (May, 2019), https://www.iai.co.il/drupal/sites/default/files/2019-05/HARPY%20Brochure.pdf [https://perma.cc/V62K-6N22] ("Harpy NG searches, identifies, acquires, attacks and destroys enemy radar targets.").

56. *See* ROYAL AIR FORCE, AIRCRAFT & WEAPONS 87 (Brian Handy, ed., 2007) (describing technology in a UK employed Brimstone missile when used in "lock after launch" mode).

57. Prosecutor v. Stanislav Galić, IT-98-29-T, Judgement, ¶ 37 (Int'l Crim. Trib. for the Former Yugoslavia Dec. 5, 2003).

58. MICHAEL N. SCHMITT, ESSAYS ON LAW AND WAR AT THE FAULT LINES 190 (2012).

59. *Id.*

60. *See* ICRC 2015 Report, *supra* note 18, at 45 (discussing the "key challenges" of proportionality).

61. *Id.*

62. *See* Michael Schmitt, *Military Necessity and Humanity in International Humanitarian Law: Preserving the Delicate Balance*, 50 VA. J. INT'L L. 795, 813 (2010) ("An assessment conducted by the U.S. military judged the treaty 'to be too ambiguous and complicated to use as a practical guide for military operation.'").

difficulty in application, the rule of proportionality is "an obligation of conduct, not simply one of results."[63]   More simply stated, Additional Protocol I requires states to take "feasible" precautions to verify the nature of the military objective prior to conducting an attack.[64] At least one expert involved in the United Nations effort to regulate LAWS has described the obligation to undertake "feasible" precautions as one of development and testing of autonomous weapons, and that these efforts must be more stringent the farther removed human beings are from the strike/no-strike decision.[65] That said, a guarantee of results[66] would be too high a bar, and that is not the standard that the LOAC requires for human actors.[67]

Concerns surrounding these four principles, as well as concerns about which personnel or officials to hold liable if a LAWS makes the "wrong" decision have lead Human Rights Watch, the ICRC, and other non-governmental organizations to focus on human control as the touchstone of the LOAC compliance.[68] However, the issue of how much human involvement is appropriate is equally contentious. The DOD requires "appropriate levels of human judgment,"[69] which at first blush appears as less involvement than that advocated by various experts involved in the CCW Group of Experts of "effective," "appropriate," or "meaningful human *control*."[70] While the specific degree of human involvement required

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63.   Kimberley Trapp, *A Framework of Analysis for Assessing Compliance of LAWS with IHL (API) Precautionary Measures*, Note to the Informal Meeting of Experts on Lethal Autonomous Weapons Systems 1 (Apr. 11–15, 2016) [hereinafter Trapp], https://www.unog.ch/80256EDD006B8954/(http Assets)/F78EF612C14FC4F8C1258074004DB93E/$file/Trapp+CCW+Informal+Meeting+of+Ex perts+(2016).pdf [https://perma.cc/54UN-LMVV].

64.   AP I, *supra* note 11, at art. 57(2).

65.   *See* Trapp, *supra* note 63, at 7 (explaining how "everything hangs on the development and testing of the technology").

66.   For example, a guarantee that a LAWS system would never attack a civilian object.

67.   *See* Trapp, *supra* note 63, at 8 (stating the standards "is simply too high for such weapons systems to pass Article 36 AP I review").

68.   *See* HUMAN RIGHTS WATCH, *supra* note 6, at 13 (noting that "[i]t is time for the broader public to consider the potential advantages and threats of fully autonomous weapons"); ICRC 2015 Report, *supra* note 18, at 45 ("In this respect, it seems evident that overall human control or oversight over the selection and attack of targets will continue to be required to ensure respect for IHL."); Trapp, *supra* note 63, at 3–4 (discussing the various aspects of human control in the context of artificial intelligence) (discussing the various aspects of human control in the context of artificial intelligence).

69.   U.S. DEP'T OF DEF., *supra* note 17, at 2.

70.   Neha Jain, *Human-Machine Interaction in Terms of Various Degrees of Autonomy as Well as Political and Legal Responsibility for Actions of Autonomous Systems*, Note to the Informal Meeting of Experts on Lethal Autonomous Weapons Systems 2 (Apr. 11–15, 2016) (emphasis added), https://www.unog.ch/80256EDD006B8954/(httpAssets)/82C5CE75F5021C3FC1257F9A004A5E

for any particular system is a critical question, it is beyond the scope of this paper. The focus of this paper is whether, and how LAWS can be employed in accordance with the LOAC. One such formulation in response to the degree of necessary human involvement question was put forth by the ICRC, writing that the "kind and degree of human control or oversight required to ensure compliance of an autonomous weapon system with IHL will depend on the type of autonomous weapon system, the tasks it is designed to carry out, the environment in which it is intended to be used, and the types of targets it is programmed to attack, among other factors."[71]

Human control and the four LOAC principles have driven the discussion by non-governmental organizations (NGOs) for a ban or restriction on LAWS. One such effort is a proposed protocol to the Convention on Certain Conventional Weapons (CCW).[72] However, any proposed Treaty banning LAWS would require the support of, and ratification by States to become binding international law.[73] With that understanding, the pursuit of LAWS by many states, at least, indicates an open debate on whether and how LAWS can be lawfully employed.[74]

B.   *State Practice in the Development and Employment of LAWS*

Despite the objections of NGOs, and as discussed in Part II of this article, states have continued to develop LAWS at an ever-increasing pace. Furthermore, states have presented their views on the applicability of the LOAC to LAWS, and whether the current rules are sufficient to deal with

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05/$file/2016_LAWS+MX+Presentations_ChallengestoIHL_Neha+Jain+oral+note.pdf [https://perma.cc/8Z9M-Y6TN]; ICRC 2015 Report, *supra* note 18, at 46.

71.   ICRC 2015 Report, *supra* note 18, at 45.

72.   More precisely this is the Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons Which May be Deemed to be Excessively Injurious or to Have Indiscriminate Effects as Amended 21 December 2001, *ratified* Apr. 8, 1982, 19 I.L.M. 1823, 1342 U.N.T.S. 137 [hereinafter CCW]. For efforts relating to LAWS, see *Background on Lethal Autonomous Weapons Systems in the CCW*, U.N. OFF. AT GENEVA (last visited June 29, 2019), https://www.unog.ch/80256EE600585943/(httpPages)/8FA3C2562A60FF81C1257CE600393DF6?OpenDocument [https://perma.cc/68EL-KBG7].

73.   CCW, *supra* note 72, at art. 4. In particular, the treaty or protocol would only be binding upon those states which ratify. Non-ratifying states would not be bound. Based on information presented at the UN Group of Government Experts, it appears unlikely that states, including the United States, United Kingdom, France, Russia, and China (many of the largest developers of autonomy in weapons systems), would ratify such a treaty or protocol. *See generally* Vienna Convention on the Law of Treaties, *entry into force* 27 January 1980, 1155 U.N.T.S. 331.

74.   Compare the Holy See, which objects primarily on ethical grounds, rather than the inability of LAWS to comply with the LOAC. *See, e.g.*, Holy See, *supra* note 10 (discussing the potential effects of LAWS and its legal implications).

new weapons systems. The answer expressed in state practice, as well as at the CCW Group of Experts, appears from many of the states most involved in developing LAWS to be "yes." As discussed, the United States, United Kingdom, Israel, and France have proceeded with development on a number of autonomous weapons systems, including those with potentially lethal effects. Furthermore, Russia has unequivocally stated that it will not support any United Nations effort to craft a generally applicable treaty-based ban on LAWS, which appears based on the Russian policy of actively pursuing such autonomous weapons systems.[75]

The French delegation to the U.N. Group of Governmental Experts (GGE) on LAWS has articulated that the LOAC in its current form is sufficient to address the challenges posed by lethal autonomous weapons.[76] France points to the requirement in Additional Protocol I, Article 36 to ensure weapons that are fielded comply with the LOAC, and indicates that any LAWS will be subject to the same review process.[77] Despite the fact that weapons may be subject to misuse in an unlawful manner, the Article 36 obligation is solely to assess the normal or intended use of the weapon.[78] With sufficient precautions, including consideration by the commander of

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75. *See* Patrick Tucker, *Russia to the United Nations: Don't Try to Stop Us From Building Killer Robots*, DEF. ONE (Nov. 21, 2017), http://www.defenseone.com/technology/2017/11/russia-united-nations-dont-try-stop-us-building-killer-robots/142734/?oref=d-topstory&utm_source=Sailthru&utm_medium=email&utm_campaign=EBB%2011.27.2017&utm_term=Editorial%20-%20Military%20-%20Early%20Bird%20Brief [https://perma.cc/JDR8-FWMM] ("Russia announced that it would adhere to no international ban, moratorium or regulation on such weapons.").

76. *See* France, Legal Framework for Any Potential Development and Operational Use of a Future Lethal Autonomous Weapons System (LAWS) 3 (U.N. Convention on Certain Conventional Weapons, 2016 Meeting of Experts on LAWS, Working Paper, Apr. 2016) [hereinafter 2016 France Working Paper] (unpublished working paper) (on file with U.N. Convention on Certain Conventional Weapons), https://www.unog.ch/80256EDD006B8954/(httpAssets)/C4D88A9E3530929EC1257F8F005A226C/$file/2016_LAWSMX_CountryPaper_France+LegalFramework+EN.pdf [https://perma.cc/BK82-XXSG] ("The current position of France's prospective analysis considers that the development and use of lethal autonomous weapons systems cannot be regarded as intrinsically contrary to international humanitarian law (IHL). Any preventive prohibition of the development of any potential LAWS would therefore appear premature.").

77. *See id.* at 1 (discussing how LAWS fall within the scope of Article 36's "weapon, means or method of warfare," providing the necessary IHL oversight for weapons development).

78. Switzerland, *A "Compliance-Based" Approach to Autonomous Weapon Systems* 2 (U.N. Convention on Certain Conventional Weapons, Working Paper No. 9, 2017) [hereinafter 2016 Switzerland Working Paper]; 2016 France Working Paper, *supra* note 76, at 1; Japan, Japan's Views on Issues Relating to LAWS ¶ 4 (Apr. 2016) [hereinafter 2016 Japan Working Paper] (unpublished working paper) (on file with U.N. Convention on Certain Conventional Weapons), https://www.unog.ch/80256EDD006B8954/(httpAssets)/4E8371EAD5E34263C1257F8C00289B5E/$file/2016_LAWS+MX_CountryPaper+Japan.pdf [https://perma.cc/9MJS-5CNU].

such factors as potential civilian casualties, the expected military advantage to be gained, the operational environment, and the characteristics of a particular weapon, there is every reason to believe that LAWS can be employed lawfully in appropriate circumstances.[79] While LAWS may not be ready for full, unfettered employment given the current state of robotics,[80] when understanding the benefits that autonomy has had in other fields such as faster calculations, and lack of emotions such as fear, panic, or a desire for vengeance, there are reasons to believe that under the right circumstances LAWS could make "better decisions" than human beings.[81]

In fact, many of the claims made by ban proponents have been characterized as misleading and based on factually incorrect assertions.[82] For instance, many ban proponents conflate autonomous systems and remotely piloted aircraft (RPA or "drones"), and then point to the argument that "drone" strikes result in higher civilian casualty rates than for manned missions.[83] The problem with this assertion is two-fold. First is that "drones" or RPAs used to conduct lethal strikes are not autonomous, but are piloted by human beings using remote means. The second concern is that some of the comparisons of "drone" and manned missions conflate dissimilar situations when making their comparison.[84] They also discuss "drone" missions outside of battlefields, where they are forced to rely on NGO casualty estimates, in comparison to manned missions in "war zones"

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79. 2016 France Working Paper, *supra* note 76, at 2–3.

80. 2016 Switzerland Working Paper, *supra* note 78, at 3.

81. *Compare* 2016 France Working Paper, *supra* note 76, at 2 ("Indeed, the use of autonomous weapons systems could reduce risks for civilians by making more accurate targeting decisions by means of faster calculation of available information and more controlled firing decisions due to the absence of negative feelings like fear, panic and a desire for vengeance."), *with* 2016 Japan Working Paper, *supra* note 78, at ¶ 3 ("The Japan Ministry of Defense has no plan to develop robots with humans out of the loop, which may be capable of committing murder.").

82. Michael N. Schmitt & Jeffrey S. Thurnher, *"Out of the Loop": Autonomous Weapon Systems and the Law of Armed Conflict*, 4 HARV. NAT'L SEC. J. 231, 268 (2013).

83. Micah Zenko & Amelia Mae Wolf, *Drones Kill More Civilians Than Pilots Do*, FOREIGN POL'Y (April 25, 2016, 3:59 PM), http://foreignpolicy.com/2016/04/25/drones-kill-more-civilians-than-pilots-do/ [https://perma.cc/UU9H-9XUZ].

84. Steven J. Barela & Avery Plaw, *The Precision of Drones: Problems with the New Data and New Claims*, E-INT'L REL. (Aug. 23, 2016), http://www.e-ir.info/2016/08/23/the-precision-of-drones-problems-with-the-new-data-and-new-claims/ [https://perma.cc/ZJU9-KSK8]. Barela argues that when correcting for these analytical errors, that RPA strikes result in marginally lower civilian casualties than manned strikes (0.067 casualties per RPA strike as compared to 0.099 per manned mission), but that RPAs are getting significantly better in that respect when considering strikes in non-battlefield scenarios (a drop from 1.699 casualties per strike in 2009 to 0.036 per strike in 2016). *Id.*

where government estimates are readily available.[85]   A categorical ban on all LAWS has been called premature, and unsupportable from a legal, policy, or "operational good sense" perspective.[86]   Still, others have argued that weapons with various levels of autonomy are already here, making a ban untenable in light of the myriad of countries developing such weapons.[87] Furthermore, echoing the comments of a number of countries during U.N. GGE meetings, some experts and policymakers have opined that the time is rapidly approaching when artificial intelligence will progress to the point that human beings are the "weakest link" in the decision-making chain.[88] Not only do these facts undermine arguments that LAWS are unlawful under the Martens Clause, they also necessitate real action on the development of lawful employment TTPs.

This being the case,[89] I recommend that autonomous capabilities, and the precautionary TTPs used to ensure their compliance with the LOAC, should be employed on a sliding scale[90] where they are inversely proportional to one another.   More simply put, the more accurately a machine can perceive and process its environment, reliably make the "right" decision in familiar circumstances, and predictably make the "right" decision in unfamiliar circumstances,[91] the less TTPs will require restrictive or robust

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85.   *Id.*

86.   Schmitt & Thurnher, *supra* note 82, at 233–34; 2016 France Working Paper, *supra* note 76, at 3; 2016 Switzerland Working Paper, *supra* note 78, at 6; Tucker, *supra* note 75.

87.   *See, e.g.*, Jack M. Beard, *Autonomous Weapons and Human Responsibilities*, 45 GEO. J. INT'L L. 617, 619–20 (2014) (discussing how many autonomous capabilities already exist in the maritime domain, and arguing that autonomous weapons are advancing too quickly for law and policy to keep up).

88.   *See* Crootof, *supra* note 32, at 1867 (indicating this is happening at DARPA); *see also* Dan Lamothe, *The Killer Robot Threat: Pentagon Examining How Enemy Nations Could Empower Machines*, WASH. POST (March 30, 2016), https://www.washingtonpost.com/news/checkpoint/wp/2016/03/30/the-killer-robot-threat-pentagon-examining-how-enemy-nations-could-empower-machines/ [https://perma.cc/Z3BB-SN3U] (noting Deputy Defense Secretary Work's comments about only delegating to machines when "things that go faster than human reaction time, like cyber or electronic warfare").

89.   Rather than having express wisdom over whether it is the right thing to do, from a moral or ethical standpoint, to rely on fully autonomous weapons.

90.   *See* Beard, *supra* note 87, at 625–26 (discussing autonomy as existing on a continuum).

91.   *See* Alan Schuller, *Autonomous Weapon System and the Decision to Kill*, JUST SECURITY BLOG (Sept. 21, 2017), https://www.justsecurity.org/45164/autonomous-weapon-systems-decision-kill/#more-45164 [https://perma.cc/M45E-EZUA] (pointing to the predictability of a machine's decision making in unfamiliar situations as the primary concern related to LAWS and the LOAC compliance).

control measures or precaution.[92]

IV.   THE TRAINING WHEELS: PROPOSED EMPLOYMENT TTPS FOR LAWS

A.   *Preliminary Considerations for Design and Implementation of TTPs*

In designing and implementing employment TTPs for LAWS, the first line that must be drawn is between inherently unlawful weapons and those weapons that are used in an unlawful manner.[93] Most of the talking points put forth by ban proponents are more about the employment of LAWS, and the fact that they are not accurate, reliable, or predictable enough for the situations in which they would be employed. This thinking views autonomy as binary; a weapon is autonomous or it is not. Contrary to this line of thinking, it is useful to think of autonomy as a spectrum, rather than an absolute state.[94] That is, there are both various degrees of autonomy, and differences in kind when discussing autonomy in different functions.[95] Autonomous capabilities have been described as impacting each step of Colonel John Boyd's "OODA" loop,[96] as well as autonomy in various systems, components, or processes.[97]

It is also apparent that capabilities in a number of autonomous arenas are progressing far beyond that believed possible by proponents of a LAWS ban. Machines have shown the ability to recognize individual human faces at accuracy rates unthinkable just a few years ago.[98] Machines have also demonstrated the ability, despite contentions to the contrary, to identify and interpret basic human emotions at a distance using radio frequency (RF) signals.[99] The larger the data set gathered and processed by the analytic

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92.   *See* Thurnher, *supra* note 44, at 82–83 (arguing that, while LAWS are presumptively legal, commanders should implement appropriate TTPs to ensure their lawful employment, and proposing certain types such as ROE, location of employment, mission considerations, and human supervision).

93.   *See* Beard, *supra* note 87, at 636 (distinguishing between inherently unlawful weapons and those that are not).

94.   *See* William C. Marra & Sonia K. McNeil, *Understanding "The Loop": Regulating the Next Generation of War Machines*, 36 HARV. J. L. & PUB. POL'Y 1139, 1155 (2013) ("As a result, '[l]ike intelligence and consciousness,' autonomy is best conceived of as existing on a spectrum.").

95.   Crootof, *supra* note 32, at 1846.

96.   Observe, Orient, Decide, Act.   *Id.*

97.   For example, autonomy to adjust a flight path and autonomy in selecting a target are categorically different when discussing lawful employment of LAWS.

98.   *See, e.g.*, Intelligence Advanced Research Project Agency (IARPA), *Face Recognition Prize Challenge (FRPC)*, IARPA, https://www.iarpa.gov/index.php/working-with-iarpa/prize-challenges/959-face-recognition-prize-challenge-frpc, [https://perma.cc/2QFR-4K7L].

99.   Choi, *supra* note 41.

algorithm of MIT's emotion sensing system, the more reliably and predictably it can be used to interpret both familiar and new emotional states.[100] As sensors, algorithms, and processing power improve, there is every reason to believe that the accuracy, reliability, and predictability of LAWS will improve at a pace similar to other advances in technology. That being the case, there is a relatively intuitive approach to designing and implementing employment TTPs to mitigate the weaknesses in any particular LAWS.[101]

For machines with high degrees of autonomy, current capabilities are likely insufficient to simply "turn them loose" on the battlefield. Thus, they would require a comprehensive approach, implementing a number of employment TTPs as precautions to account for this lack of capability. However, the more accurate, reliable, and predictable LAWS become, the less robust or comprehensive would those TTPs need to be. Furthermore, because different systems may have greater degrees of autonomous capability in different functions, the precautionary TTPs employed may vary from system to system. Regardless, rather than looking for a single "silver bullet" to solve all shortfalls of LAWS, a comprehensive, multidisciplinary approach to mitigating their shortfalls should be employed.[102] These mitigation TTPs can be broadly divided into Mission Design Controls, Capability Design Controls, and "Cognitive" Design Controls.

B.   *Autonomous Weapon System Employment TTPs*

1.   Mission Design Controls

For the purposes of this article, the concept of mission design controls means the employment of various constraints on the missions with which LAWS are tasked. These constraints may be temporally based, spatially

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100. *Id.*

101. The United States' position is that employment of LAWS includes the responsibility to develop adequate training, TTPs, and doctrine to understand the functioning, capabilities, and limitations of LAWS in realistic environments. United States, *Human-Machine Interaction in the Development, Deployment and Use of Emerging Technologies in the Area of Lethal Autonomous Weapons Systems* 3 (Group of Gov't Experts of the High Contracting Parties to the Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons Which May Be Deemed to Be Excessively Injurious or to Have Indiscriminate Effects, Paper No. 6, 2018), [hereinafter 2018 U.S. Working Paper]. This requirement includes periodic review by system operators and commanders to ensure continued operational relevance, and a thorough understanding of the limitations and appropriate circumstances for employment of such LAWS.

102. Schuller, *supra* note 91.

based, or target based. The concept is to adequately scope the mission of a LAWS to its capabilities in terms of sensory, analytical, and decision making capabilities. The first mitigation method is more of a question of mission assessment rather than a TTP. It is a core tenet of leadership that a commander must only "employ [his] unit in accordance with its capabilities."[103] The same concept should apply to LAWS, and they should only be employed in missions or operational environments commensurate with their capabilities to ensure that they are employed in a manner consistent with the LOAC. United States Government policy is to ensure that commanders must use weapons in a manner consistent with their design, testing, certification, and operator training.[104] This requirement is to ensure that systems always achieve the commander's intent, effectively leaving the decision of when and whether to use force up to a human commander.[105] With this in mind, inherent in any operational design is an understanding of the operational environment in which LAWS would be employed. If there are portions of the operational environment to which the particular LAWS are unsuited, then an assessment should also be made as to whether there are certain areas to which they are suited. The concept of time and space[106] deconfliction is common in warfighting organizations around the world.

For instance, allied forces often employ the concept of a restrictive fire plan or restricted fire area.[107] These are fire support coordination measures put in place which restrict fires, and the effects of fires, in certain areas as a way to establish air and ground maneuver space that is reasonably free from the effects of friendly fire.[108] United States military doctrine also requires an assessment of potential civilian casualties when planning fire support or other lethal actions,[109] and fires elements are further required to develop procedures to minimize collateral damage or effects on civilian objects.[110]

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103. MARINE CORPS WARFIGHTING PUBLICATION 6-10, LEADING MARINES 2-6 (May 2, 2016) [hereinafter MCWP 6-10].

104. *See* U.S. DEP'T OF DEF., *supra* note 17, at § 4(a) ("Autonomous and semi-autonomous weapon systems shall be designed to allow commanders and operators to exercise appropriate levels of human judgment over the use of force.").

105. 2018 U.S. Working Paper, *supra* note 101, at 3.

106. *See, e.g.*, *id.* (describing the use of geographic boundaries with LAWS would be employed).

107. NATO, NATO GLOSSARY OF TERMS AND DEFINITIONS (AAP-6) 2-R-8 (2013).

108. *Id.*

109. ARMED FORCES OF THE U.S., JOINT PUBLICATION 3–09: JOINT FIRE SUPPORT xv–xvi (2014) [hereinafter JP 3-09].

110. *Id.* at II-7, III-15.

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Part of these precautionary measures include the implementation of restrictive fire support coordination, or control measures that impose restrictions on the ability of fires elements to conduct lethal action in certain areas.[111] Such measures include restricted fires lines (RFLs),[112] no-fire areas (NFA),[113] and restricted fires areas (RFAs).[114] Of course, if fires restrictions alone are insufficient, they could also be paired with maneuver and airspace control measures. These types of measures include boundaries across which fires and movement are restricted without appropriate coordination,[115] or various airspace control measures that restrict aircraft travel.[116]

Many of these concepts of time and space deconfliction have already been applied to LAWS in various contexts. Appropriate time and space constraints on the employment of LAWS can help to mitigate the difficult question of proportionality, by ensuring that LAWS are employed in areas where they can reasonably be expected to encounter only valid military objectives.[117] The question of proportionality is highly context-dependent, and can vary based on time.[118] Because the question of proportionality is so context dependent, the answer is to employ LAWS in a manner that minimizes the possibility for relevant change in that context. This can be done by making intelligent, informed employment decisions such as deploying LAWS in areas reasonably expected to be free of civilians and civilian objects.[119] Alternatively, LAWS could be employed for short periods of time, during which a commander would have reasonable certainty that only valid military targets would be within the engagement area. For instance, the South Korean military employs the SGR-1 along the Korean

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111. *Id.* at App. 1.

112. RFLs prohibit fires, or the effects of fires, across the RFL line without prior coordination with the affected force or battlespace owner. *Id.* at A-12.

113. NFAs prohibit fires within a certain, predefined area. *Id.* at A-12.

114. RFAs impose specific restrictions on fires within the area, and any fires that exceed those restrictions are not permitted unless coordinated with/approved by the headquarters which established the RFA.

115. JP 3-09, *supra* note 109, at A-14.

116. These include air corridors, in which aircraft are confined to travel; restricted operations zones, in which the airspace is reserved for only specific activities (e.g., ISR); and no fly areas, in which no aircraft are permitted without approval of the appropriate commander. *Id.* at A-16.

117. Crootof, *supra* note 32, at 1876–77.

118. HUMAN RIGHTS WATCH, *supra* note 6, at 32.

119. While such circumstances may be limited in recent military operations against non-state actors, this may not always be the case.

De-Militarized Zone (DMZ), where human beings can be presumed to be hostile attackers from North Korea (DPRK).[120]

Lethal Autonomous Weapon Systems could also be employed in defensive roles, and be programmed only to attack targets that meet a very specific threat signature.[121] This method is employed by the U.S. Close in Weapons System (CIWS) and British PHALANX,[122] as well as the U.S. C-RAM.[123] The accurate identification of a threat is simplified in these systems, as they are programmed to identify the signatures of incoming missile or rocket threats, which are relatively easily distinguished from any civilian non-combatant.[124] Defensive employment also mitigates the risk of an improper offensive engagement, as it can be based on very strict and specific criteria to identify a threat.

Another potential employment TTP is to place constraints on the mission with which LAWS are tasked, commensurate with their sensor and analytical capabilities. It is entirely possible to have an autonomous system with lethal capabilities, but under the circumstances to make the decision that it will only be employed in non-lethal missions. The U.S. Navy is developing the Sea Hunter, which includes mine hunting, tracking, and navigation capabilities.[125] However, it is contemplated that the Sea Hunter would also have anti-submarine warfare capabilities, including lethal capabilities, depending upon the mission tasking.[126] The same is true of the U.S. Navy's developmental Wave Glider unmanned underwater vehicle (UUV).[127] The question of whether the employment of those lethal capabilities is appropriate in a given situation must be assessed by the commander, prior to employment. Autonomous systems have already shown the ability to combine a visual sensor array, an image library for comparison, an image recognition algorithm, and human operator input and refinement to

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120.   Schmitt & Thurnher, *supra* note 82, at 238 n.26.
121.   Int'l Comm. of the Red Cross (ICRC), Views of the International Committee of the Red Cross (ICRC) on Autonomous Weapon Systems 2 (Apr. 11, 2016) (unpublished working paper) (on file with the LAWS Group Governmental of Experts) [hereinafter 2016 ICRC Working Paper].
122.   Beard, *supra* note 87, at 630–31.
123.   Essentially a ground-based variant of the CIWS. *supra* note 6, at 9–10.
124.   2016 ICRC Working Paper, *supra* note 121, at 2; ICRC 2015 Report, *supra* note 18, at 45.
125.   Beck, *supra* note 24.
126.   *Id.*
127.   Peck, *supra* note 25.

recognize targets at a rate of 99% accuracy.[128] The same concept could also be applied to enemy vehicles during an armed conflict. If a particular enemy vehicle[129] has a sufficiently recognizable visual signature, and an autonomous weapon is employed in an area in which it is likely to encounter such vehicles, then there is every reason to believe that the autonomous weapon could sufficiently distinguish between military objectives and civilian objects.[130]

Facial recognition capabilities are also rapidly improving, and the U.S. Government is actively encouraging commercial development of those capabilities.[131] Chinese[132] and Russian[133] firms have demonstrated the ability—as part of the Intelligence Advanced Research Projects Agency's (IARPA) Face Recognition Prize Challenge—to identify with high degrees of speed and accuracy photographs of known persons, including in situations when the photograph being compared is compromised by poor illumination, motion blur, or other suboptimal conditions.[134] The Russian firm has also developed software that has shown the ability to match photographs of random strangers on Russian social media sites.[135] Just as with non-human target recognition, facial recognition software could be used to target known enemy high-value individuals. Once this ability to

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128.   Evan Ackerman, *Poison Injecting Robot Submarine Assassinates Sea Stars to Save Coral Reefs*, IEEE SPECTRUM (Sept. 3, 2015), http://spectrum.ieee.org/automaton/robotics/industrial-robots/poison-robot-submarine [https://perma.cc/BHE4-UVLC].

129.   For example, tanks, armored personnel carriers, etc.

130.   Such a signature recognition capability appears to be in use with the United States' Sensor Fuzed Weapon, and the BLU-108 submunition. *BLU-108/B Submunition*, GLOBALSECURITY.ORG, https://www.globalsecurity.org/military/systems/munitions/blu-108.htm [https://perma.cc/CQE3-L9A9]. Each submunition consists of 4 "pucks," equipped with a combination of active laser and passive infrared sensors to identify target vehicles. *Id.* In the absence of target vehicles, the "puck" submunition self-destructs after a given time. *Id.* (discussing the BLU-108 component of the Sensor Fuzed Weapon).

131.   *See* Intelligence Advanced Research Project Agency (IARPA), *supra* note 98 (inviting software developers to register for the "Face Recognition Prize Challenge").

132.   *Yitu Tech Wins 1st Place in Identification Accuracy in Face Recognition Prize Challenge 2017*, PR NEWSWIRE (Nov. 3, 2017), https://www.prnewswire.com/news-releases/yitu-tech-wins-the-1st-place-in-identification-accuracy-in-face-recognition-prize-challenge-2017-300549292.html [https://perma.cc/M4F5-HW4A].

133.   Immanuel Jotham, *Russian Tech Firm Wins US Intelligence Agency's Facial Recognition Software Competition*, INT'L BUS. TIMES (Nov. 9, 2017), http://www.ibtimes.co.uk/russian-tech-firm-wins-us-intelligence-agencys-facial-recognition-software-competition-1646588 [https://perma.cc/8PEV-6WPE].

134.   *Yitu Tech Wins 1st Place in Identification Accuracy in Face Recognition Prize Challenge 2017*, *supra* note 132.

135.   Jotham, *supra* note 133.

distinguish is established and refined, then the question of proportionality can be addressed by employing these mission limitations in combination with the time and space deconfliction concepts discussed previously.

2.   Capability Design Controls

Assignment of particular missions should also be paired with, and based upon the capabilities of any particular LAWS.   For the discussion on "capabilities", the focus will remain on the physical and sensory capabilities of a particular autonomous system, while capabilities relating to algorithmic processing and decision making will be addressed in the section on "cognitive" design.   The U.S. military is actively researching a number of non-lethal capabilities.[136]   These include weapons such as the Active Denial System (ADS),[137] optical or laser dazzlers,[138] as well as weapons that use the electromagnetic spectrum to disable enemy equipment.[139]   At a less experimental level, U.S. Coast Guard Academy cadets have tested the concept of arming off-the-shelf drones[140] with a variety of non-lethal weapons such as pepper spray and propeller nets in an effort to counter drug smuggling TTPs that exploit the Coast Guards' "no-kill"

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136.   Rosa Brooks, *Can There Be War Without Soldiers?*, FOREIGN POLICY (March 16, 2016), http://foreignpolicy.com/2016/03/15/can-there-be-war-without-soldiers-weapons-cyberwarfare/ [https://perma.cc/D87T-MFA7].

137.   *Id.*   The ADS is effectively a millimeter wave emitter that makes the target feel an extreme sensation of heat, which abates as soon as the person moves out of the targeted area (the "repel effect"). The ADS is currently in development as a vehicle mounted capability, and has an effective range of several hundred meters.   Although fielded, the ADS has never been employed on a battlefield.   *See Active Denial Technology*, JOINT NON-LETHAL WEAPONS PROGRAM, http://jnlwp.defense.gov/Future-Non-Lethal-Weapons/Active-Denial-Technology/ [https://perma.cc/A4YU-X2YG] ("Active Denial Technology is a non-lethal, counter-personnel capability that creates a heating sensation, quickly repelling potential adversaries with minimal risk of injury."); John M. Kenny, et al., *A Narrative Summary and Independent Assessment of the Active Denial System*, PENN STATE APPLIED RESEARCH LAB. 16 (Feb. 11, 2008) (describing the normal and intended use of the ADS).   While the millimeter wave technology can cause heat injuries (superficial burns) with extended exposure, that there is a wide safety margin between the length of exposure that produces the "repel effect," and the length of exposure that could cause either first or second degree burns.

138.   Kenny, et. al., *supra* note 137.   Used to temporarily "blind" a target through visual disorientation.

139.   *Id.*

140.   Julia Bergman, *Cadets Turn to Drones for Non-Lethal Method to Stop Drug Boats*, THE DAY (March 15, 2016), http://www.theday.com/military/20160315/cadets-turn-to-drones-for-non-lethal-method-to-stop-drug-boats [https://perma.cc/U8DU-QJJK].   While not autonomous, there is every reason to believe that an autonomous counterpart with similar physical capacity could be similarly equipped.

policy.[141] These types of non-lethal weapons and precautionary TTPs are specifically designed to limit collateral damage, reduce risk to civilians, and enhance the military's ability to separate civilians from combatants.[142] While autonomous weapon systems equipped solely with these non-lethal capabilities would not be LAWS, there are two ways in which LAWS could be paired with such non-lethal means.

The first would be to equip sufficiently capable autonomous systems with a range of non-lethal capabilities in addition to one or more lethal capabilities.   Such an autonomous system could then employ a preprogrammed escalation of force (EOF) protocol.[143] These protocols provide tools and guidance to a service member that can be used to both de-escalate situations, as well as to further refine a determination as to whether an individual presents a threat.[144] By employing an escalation from visual warnings, to auditory warnings, non-lethal means, and then lethal means, a service member (or in this case, an autonomous system) could both avoid civilian casualties and further identify potential threats.[145] Another method would be to effectively "team" a number of autonomous systems equipped with non-lethal capabilities alongside those equipped with lethal capabilities, and employing a similarly preprogrammed escalation of force protocol. These courses of action—equipping autonomous systems with a range of non-lethal and lethal capabilities or teaming non-lethal systems with lethal ones—could be superior to the human employment of the EOF protocols for two reasons.

First, U.S. military members in combat zones are taught that the EOF procedures are not a rigid checklist, but guidelines.[146] If the situation necessitates, a service member may skip any or all of the steps in the EOF protocol, and immediately resort to lethal force.[147] Because autonomous

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141.   *Id.* In essence, drug smugglers will lay across the engine block to defeat the USCG tactic of using an anti-materiel round (.50 BMG) to disable an engine. *Id.* NLW that get a smuggler to move off of the engine block could prove an effective counter, allowing the USCG to then employ an otherwise lethal means to disable the engine.

142.   JP 3-09, *supra* note 111, at xvi; Joint Publication 3-28, Defense Support of Civil Authorities III-9 (July 31, 2013) [hereinafter, JP 3-28].

143.   For example, the "show, shout, shove, shoot" methodology. *Escalation of Force Handbook: Afghanistan*, CENTER FOR ARMY LESSONS LEARNED 61–62 (Dec. 2009); *Law of War, Rules of Engagement, and Escalation of Force Guide*, MARINE CORPS CENTER FOR LESSONS LEARNED 412 n.385 (Sept. 24, 2007).

144.   *Law of War, supra* note 143, at 23–26.

145.   *Id.*; *Escalation of Force Handbook: Afghanistan, supra* note 143.

146.   *Escalation of Force Handbook: Afghanistan, supra* note 143, at 59–62, 64, 68–70, 57–58, 66, 77.

147.   *Id.*

weapons would not have the same self-preservation instincts as human beings, they could more rigidly apply those EOF procedures, even if it meant sacrificing one or more of the weapon platforms. Secondly, if a target persists in a hostile act after the employment of EOF procedures, then it would assist the LAWS in making the distinction necessary to identify a potential target as hostile.[148] A sample EOF procedure could be the employment of auditory warnings such as the Long Range Acoustic Device (LRAD), followed by visual signals from flares or the aforementioned laser dazzlers,[149] and finally the employment of various non-lethal weapons such as the ADS or pepper spray. The ability to employ this range of capabilities prior to lethal force provides critical information which could contribute to both greater accuracy in a LAWS' identification of a potential threat, as well as reduced consequences of making an incorrect determination.[150] Autonomous systems, either individual or teamed,[151] could be programmed to only employ lethal force after first employing each of these EOF steps, and thereby failing to neutralize the threat.

This appears to be a TTP employed by some autonomous systems already. For example, the Israeli Guardian is an autonomous ground system that can be armed with a variety of both lethal and non-lethal payloads.[152] In addition, the South Korean SGR-1 is programmed to employ verbal commands prior to target engagement.[153] While the SGR-1 is not currently employed in a fully autonomous mode,[154] it does have a fully autonomous capability in the event no human operator is available.[155] Employment of verbal warnings, or any other non-lethal weapon prior to employing lethal

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148.   U.S. Dep't of Def. Directive No. 3000.03E, DoD Executive Agent for Non-Lethal Weapons (NLW), and NLW Policy (Apr. 25, 2013 (W/Ch. 1, Sept. 27, 2017)) [hereinafter, DoDD 3000.03E]; JP 3-09, *supra* note 111, at xvi.

149.   Brooks, *supra* note 136.

150.   A description of EOF can be found on the Joint Non-Lethal Weapons Directorate FAQ page. *Non-Lethal Weapons FAQS*, Non-Lethal Weapons Program, http://jnlwp.defense.gov/ About/Frequently-Asked-Questions/Non-Lethal-Weapons-FAQs/   [https://perma.cc/9H92-UT WU]. NLW provides a solution to the "gap" between auditory warnings ("shout") and lethal force ("shoot"). *Id.* It permits a service member, or LAWS to "detect, delay, deny, and defeat" potential threats with greater accuracy and less collateral damage. *Id.*

151.   Teaming could include teaming with other systems, human operators, or both.

152.   Crootof, *supra* note 32, at 1869–70.

153.   *Id.* at 1869.

154.   *Id.* As currently employed, there is apparently always a human operator making the "shoot/no-shoot" decisions.

155.   *Id.*

force, by the SGR-1 or other LAWS would appear to be a matter of simple programming.

Similarly, tied to both the concept of distinction and the concept of mission design, is the TTP of pairing a system's potential targets with its sensors. Put another way, this ensures that a particular LAWS only sees the target that a force wishes to attack. Pairing a system's potential targets with its sensors would require the employment of technology which includes a library of only acceptable targets,[156] and then employing a lethal capability only when the LAWS receives specific sensor input that matches the acceptable template of that target.[157] In essence, only allow the weapon to strike what it "sees," and only let it "see" potential targets.[158] For instance, the Israeli Harpy/Harop is an expendable UAV that is intended to target enemy radar arrays.[159] The Harpy/Harop is equipped with a list of potential target frequencies, and strikes when it "sees" a radar emission signature that matches one in its target library.[160] The United Kingdom's Brimstone missile employs a similar capability when employed in "lock after launch" mode, in that it compares what it "sees" to a catalog of known enemy target signatures.[161] The U.S. Navy and Defense Advanced Research Projects Administration (DARPA) have also developed an unmanned surface vehicle (USV/ACTUV) that is designed to track quiet diesel-electric submarines.[162] In order to identify potential targets, USV/AVTUV identifies and tracks enemy submarines from the surface using unique pairings of sonar and acoustic signatures.[163]

Machines with remote sensors have also shown the capability to sense emotional states such as stress by reading physiological inputs like pulse,[164] or other emotions through recognition of facial expression patterns.[165] Autonomous systems have also demonstrated highly accurate facial recognition—including in less than ideal circumstances—in U.S.

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156.   Tucker, *supra* note 75.

157.   Beard, *supra* note 87, at 629–30.

158.   Crootof, *supra* note 32, at 1874.

159.   *Harpy*, IAI, https://www.iai.co.il/p/harpy (last visited July 22, 2019) [https://perma.cc/9YEA-6KHV].

160.   Crootof, *supra* note 32.

161.   ROYAL AIR FORCE, *supra* note 56.

162.   Gady, *supra* note 24.

163.   *Id.*

164.   MACDUFF ET AL., *supra* note 39, at 4001.

165.   Choi, *supra* note 41.

Intelligence Community sponsored research and competitions.[166] Jack Gallant's research has also demonstrated that machines are capable of effectively "reading minds," and while that capability currently requires physical contact of electrodes with a person's head,[167] it is foreseeable that the machines could develop the ability to perceive and process brain activity at a distance. These capabilities undercut assertions that LAWS would be incapable of distinguishing a civilian from a combatant, as they would be unable to understand human emotion.[168] The use of appropriate sensors, combined with signature identification algorithms, machine learning, and human operator refined decision making also lead into the next discussion of "cognitive" design based mitigation measures.

3.   Cognitive Design Controls

"Cognitive" based controls mean that the degree of automation, or the extent to which a LAWS is "turned loose" in the operational environment, varies based upon its ability to perceive and process its environment. Cognitive based controls is not a new concept, as authors have previously identified that the level of automation that is appropriate varies according to the task to be performed. For instance, given the current state of robotics[169] machines tend to be better suited to repeatable processes and predictable situations in which a single, rote response is appropriate;[170] whereas human beings tend to perform at a superior level in uncertain situations that require expertise or "intuition."[171] The limitations on machines generally relate to their ability to reliably and predictably sense their environment, process the inputs from their various sensors, and appropriately respond when a situation is new or different from those contemplated when developing its programming.[172] These limitations are based on the fact that most machine learning is based on statistical analysis

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166.   Intelligence Advanced Research Project Agency (IARPA), *supra* note 98.

167.   Nishimoto et al., *supra* note 42. Part of the research team's conclusion is that dynamic brain activity, not specific to only visual experiences, can be decoded using MRI technology.

168.   HUMAN RIGHTS WATCH, *supra* note 6, at 28.

169.   Or at least the state of robotics in 2014. Beard, *supra*, note 87, at 629–30.

170.   Mary Cummings, *Man Versus Machine or Man + Machine?*, IEEE INTELLIGENT SYS., Sept.–Oct. 2014, at 2, 3 tbl.1. In the context of LAWS, this is generally termed "automated" as opposed to "autonomous."

171.   *Id.* at 2, 3.

172.   *Id.* at 2, 5–8.

and pattern matching.[173] Without a sufficient baseline for comparison of a new situation, this machine learning breaks down. Given these limitations, the level of automation appropriate to a given situation decreases, the further a task moves away from learned skills or repetitive tasks, and toward the application of knowledge to new or uncertain situations.[174] For those tasks requiring a higher degree of knowledge or improvisation, manned/unmanned teams have produced superior results to either of those "team members" acting alone in tasks as varied as chess, and search and rescue.[175] The U.S. Department of Defense is already evaluating and advocating for this concept of manned/machine teaming;[176] Deputy Secretary of Defense Robert Work described a system in which a manned fighter would "lead" a swarm of Unmanned Combat Aerial Vehicles (UCAV) in combination with an "aerial artillery" platform.[177]

One of the concerns raised with manned/unmanned teaming is that of mere human "ratification" of the decision of the machine, where a human operator is incapable of second-guessing the assessment and decision made by a computer.[178] To avoid such an outcome, the type and degree of human oversight should be scoped to the capability of the machine. For instance, where an autonomous system is less capable of making the appropriate decision, then a system of vehicle-based supervisory control

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173. *Id.* at 2, 8. This type of learning is sometimes called the "search and filter" approach, where the machine processes data until it finds something in its memory that approximates a close enough match to its sensor inputs.

174. *Id.* at 2, 5–8, 8 tbl.3.

175. *Id.* at 2, 8.

176. Clay Dillow, *The Pentagon Wants Autonomous Fighter Jets to Join the F-35 in Combat*, FORTUNE (Mar. 30, 2016), http://fortune.com/2016/03/30/autonomous-fighter-jets-join-the-f-35/ [https://perma.cc/T227-JJTZ].

177. Jules Hurst, *Drones and the Future of Aerial Combined Arms*, WAR ON THE ROCKS (May 12, 2016), http://warontherocks.com/2016/05/drones-and-the-future-of-aerial-combined-arms/ [https://perma.cc/8QAN-924Q]. The "aerial artillery" platform would essentially be a large platform aircraft, armed with heavier weapons including both air-to-air, and air-to-surface attack capabilities. *Id.* This platform would serve the dual roles of heavy weapons platform, and command and control (C2) node for the manned fighter and UCAV swarm. *Id.* The concept is also being employed in the civilian conservation arena, yet again, in the form of COTSBot, which currently uses an "in the loop" model by relaying an image of a suspected COTS to an operator, and the operator then makes the kill/no-kill decision. However, COTSBot still employs a level of machine learning, as it continues to "learn" and refine its identification ability by both amassing a larger data set for comparison of suspected COTS, and improving accuracy with human input. *New Robot has Crown-of-Thorns Starfish in its Sights*, *supra* note 35.

178. Allyson Hauptman, *Autonomous Weapons and the Law of Armed Conflict*, 218 MIL. L. REV. 170, 186–87 (2013).

(VBSC) in which an operator supervises one or more vehicles individually may be appropriate.[179] Whereas, when individual LAWS become more capable, then it may be appropriate to shift to a system based supervisory control (SBSC) model, in which a single operator monitors a system composed of numerous individual vehicles.[180] This model of supervisory control has been validated as a means to control swarming vehicles,[181] as well as the fastest model for integrating/controlling UAVs on aircraft carrier flight decks.[182] Similar capabilities have been validated in the context of civilian air traffic control operations.[183] In addition to the method of supervision, and the number of vehicles supervised by a human operator, the character of supervision should be considered as well.

There is often a discussion as to whether LAWS would require an affirmative operator decision to engage a target,[184] or whether it is sufficient that a human operator has the authority to override or "veto" a machine's decision to engage a target.[185] These concepts are often referred to respectively as "in the loop," or "on the loop."[186] There are several concerns with "on the loop" systems, in which the operator would exercise only an override. The first is that, in the absence of sufficient time for the operator to independently assess the situation before the machine acts, then this effectively becomes an "out of the loop" system, in which the operator

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179.   JASON C. RYAN & MARY L. CUMMINGS, A SYSTEMS ANALYSIS OF THE INTRODUCTION OF UNMANNED AIRCRAFT INTO AIRCRAFT CARRIER OPERATIONS 8 (2019), https://hal. pratt.duke.edu/sites/hal.pratt.duke.edu/files/u35/ATR_CEDM%20final%20R1%20updated.pdf [https://perma.cc/UEK6-D539]. It may be appropriate to start with "one vehicle, one operator," and shift to having a single operator supervise multiple vehicles as LAWS become more capable, reliable, and predictable. Note, however, that the upper limit of a human operator to supervise individual vehicles appears to be in the neighborhood of eight to twelve vehicles per operator. *Id.* Ryan and Cummings also evaluated a "gesture based" supervisory control, in which autonomous systems would take cues from gestures by human operators. *Id.* This was the least effective form of control and appeared related to deficiencies in the machine's ability to both recognize discrete gestures and process those gestures as quickly as either human pilots or the machines taking direction from other supervisory systems. *Id.*

180.   *Id.*

181.   Drew, *supra* note 20.

182.   *Id.*

183.   Miles C. Aubert et al., *Toward the Development of a Low-Altitude Air Traffic Control Paradigm for Networks of Small, Autonomous Unmanned Aerial Vehicles*, AM. INST. AERONAUTICS & ASTRONAUTICS, INC., Jan. 2015, at 1.

184.   HUMAN RIGHTS WATCH, *supra* note 6, at 2; Trapp, *supra* note 63, at 4–5.

185.   M. L. CUMMINGS ET AL., *Functional Requirements for Onboard Intelligent Automation in Single Pilot Operations*, *in* AM. INST. OF AERONAUTICS & ASTRONAUTICS INFOTECH CONFERENCE 6 (2016); Schmitt & Thurnher, *supra* note 82, at 235–36.

186.   Hauptman, *supra* note 178, at 185 n.52.

has no real input or override authority.[187] Similarly, if a system or swarm under human supervision becomes too large, then a human being may be unable to process the myriad inputs from all of the disparate individual vehicles in order to monitor the total system effectively.[188] A final concern is that of operator bias in the form of a reluctance or inability to second-guess the machine.[189] While LAWS in their current state likely require an operator "in the loop" in order to pass Article 36 weapons review muster,[190] it is by no means true that this should always be the case. For instance, with certain types of threats, defensive LAWS, such as the U.S. Navy's Close in Weapons System (CIWS) and the Army Counter Rocket, Artillery, Mortar (C-RAM) systems, are able to autonomously identify, track, and destroy threats such as enemy anti-ship missiles or incoming rocket or artillery fire.[191]

On the one hand, there is some merit to the argument that, although the CIWS and C-RAM are LAWS, they are less prone to mistakes about distinction and proportionality because they are anti-material weapons, rather than anti-personnel weapons. They are designed to identify, track, and destroy only those targets that move and behave inapposite to humans or manned targets, making it either unlikely or impossible to accidentally target a human being.[192] In fact, this statistical unlikelihood stems from modern technology, which is capable of readily identifying the unique signatures associated with anti-ship missiles, rocket fires, or mortar rounds. As sensing, processing, and algorithmic technology improves, other forms of threats may be just as easily recognized, despite the difficulty of their ready recognition given current technology.[193] Thus, the more accurately machines are able to perceive and process their environment; the less reliant

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187.   Schmitt & Thurnher, *supra* note 82.

188.   HUMAN RIGHTS WATCH, *supra* note 6, at 19.

189.   *See* Hauptman, *supra* note 178, at 186 (discussing the U.S. Navy's C-RAM system that has such quick reaction time that humans have less time for corrective action).

190.   Trapp, *supra* note 63, at 8 (quoting the Protocol Additional to the Geneva Conventions of 12 August 1949, and Relating to the Protection of Victims of International Armed Conflicts (Protocol I), of 8 June 1977, art. 36, *opened for signature* 12 Dec. 1977, 1125 U.N.T.S. 3). The United States has not ratified AP I, but does perform legal reviews on all new weapons, including weapon systems incorporating autonomous capabilities. *See* U.S. DEP'T OF DEF., *supra* note 17, at 8 ("Incorporating Change 1, May 8, 2017"); U.S. DEP'T OF DEF., DIRECTIVE NO. 5000.01, THE DEFENSE ACQUISITION SYSTEM 2 (Nov. 21, 2007) ("provid[ing] management principles and mandatory policies and procedures for managing all acquisition programs.").

191.   Crootof, *supra* note 32, at 1858–59.

192.   *Id.* at 1875.

193.   *Id.* at 1867; Lamothe, *supra* note 88.

LAWS should be on the humans, either "in" or "on" the loop, to oversee engagement decisions.

V. CONCLUSION

In summary, calls for a pre-emptive, and all-encompassing ban on LAWS are not simply premature; they are based on incorrect legal and factual assertions about the current and potential capabilities of LAWS.[194] Furthermore, the less capable LAWS are, then the more robust or extensive control measures should be to mitigate that lack of capability. As LAWS become increasingly capable, then those control measures can be lessened in a way that can more fully utilize the autonomous capabilities of LAWS in an operational environment commensurate with their capabilities in order to ensure employment in accordance with the LOAC.

The critical concerns are whether the employment of LAWS comply with the LOAC. The most contentious area of debate is whether LAWS can accurately, reliably, and predictably distinguish between civilians and combatants.[195] There is also the difficult question of proportionality; the highly context-dependent balancing of the military advantage to be gained against the expected harm to civilians or civilian objects.[196] As described below, when paired with the appropriate control measures, and employed in an appropriate operating environment, not only could LAWS be employed in compliance with the LOAC in the future; there is every reason to believe that LAWS could do so today.

Current autonomous capabilities include swarm communications and actions,[197] and manned/unmanned teaming.[198] Such systems could be paired with vehicle-based supervisory control measures, and as they become more capable, could shift to a system based supervisory control system.[199] This has promise when considering the improvement seen in manned/unmanned teams, as compared to all manned or all unmanned teams.[200] These types of control measures could also be paired initially with "human-in-the-loop," decision making, which could shift to "human-on-

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194. Schmitt & Thurnher, *supra* note 82, at 232–33.

195. ICRC 2015 Report, *supra* note 18, at 45.

196. *Id.*; SCHMITT, *supra* note 58.

197. Hardy, *supra* note 19.

198. Cummings, *supra* note 170, at 2, 8.

199. Ryan & Cummings, *supra* note 179.

200. Cummings, *supra* note 170, at 2, 8 (demonstrating the superior outcomes from deploying a combination of manned, and autonomous/unmanned teammates).

the-loop," and perhaps even eventually "human-out-of-the-loop," systems as machines become more capable.[201]

Other potential measures to mitigate deficiencies in the capabilities of LAWS include mission design and capability design. This could include the mission with which LAWS are tasked, such as defensive missions,[202] mine hunting/clearance,[203] or targeting only a very specific signature readily associated with a legitimate military target.[204] A myriad of geographic, air/sea space, or fire control measures could be implemented to ensure that LAWS only employ lethal capabilities in areas where their lack of capability would not be expected to impact the ability to employ them in accordance with the LOAC.[205] These measures could include employment in an area where only hostile threats would be expected,[206] or by establishing "no fire areas" where LAWS are not permitted to employ lethal capabilities.[207] Capability design controls would include sensor configurations that ensure LAWS only "see" the targets that they are supposed to strike.[208] It could also include the integration of lethal and non-lethal capabilities,[209] and building escalation of force procedures—the "show, shout, shove, shoot" model—into the LAWS weapons employment protocols. These combinations of capability, mission, and cognitive controls must be employed in a holistic, and complementary manner to address deficiencies in LAWS' capabilities comprehensively.

A comprehensive system of control measures, tailored to the specific capabilities of a particular system, can effectively ensure that LAWS are employed in accordance with the LOAC regardless of the operating environment. Furthermore, it is no mystery that the ability of computers to

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201.   Schmitt & Thurnher, *supra* note 82, at 235 n.12.

202.   Beard, *supra* note 87, at 619; HUMAN RIGHTS WATCH, *supra* note 6, at 9–10.

203.   Beck, *supra* note 24.

204.   *See* ROYAL AIR FORCE, *supra* note 56 (describing the ability of the Brimstone missile to identify, and lock onto specific enemy target signatures).

205.   *See generally* JP 3–09, supra note 109, at A-1 to A-2 ("provid[ing] fundamental principles and guidance for planning, coordinating, executing, and assessing joint fire support during military operations.").

206.   Crootof, *supra* note 32, at 1876–77.

207.   *See generally* JP 3–09, *supra* note 109, at A–2 ("Restrictive measures safeguard friendly forces and include airspace coordination areas (ACAs), restrictive fire lines (RFLs), no-fire areas (NFAs, restrictive fire areas (RFAs), and ZFs.").

208.   *See* Crootof, *supra* note 32, at 1871 (describing the dedicated precision of the Israeli Harpy expendable UAV); *New Robot has Crown-of-Thorns Starfish in its Sights*, *supra* note 35.

209.   Either in a single LAWS, or by integrating a LAWS with manned/unmanned teammates that are armed only with non-lethal capabilities.

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input and process data is increasing at an exponential rate. The majority of Americans, and indeed the majority of people worldwide, now effectively carry computers in their pockets that outstrip the bounds of the imagination a mere twenty years ago. When paired with the capabilities and possible associated control measures mentioned above, this massive increase in electronic analytical capability may very soon make machines the superior option from a LOAC compliance standpoint.