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The thoughts and opinions expressed are those of the authors and not necessarily of the U.S. government, the U.S. Department of the Navy, the U.S. Naval War College, the UK government, the UK Ministry of Defence or the Royal Navy.

I. INTRODUCTION

In any armed conflict, the right of the parties to the conflict to choose methods or means of warfare is not unlimited.[1] For example, it is prohibited to employ weapons that cause superfluous injury or unnecessary suffering, or weapons that are inherently indiscriminate, including weapons that cannot be aimed or whose effects cannot be controlled.[2] Few would deny that these are fundamental tenets of the law of armed conflict.[3] To support these basic rules, Article 36 of Additional Protocol I requires legal reviews of all new weapons, means and methods of warfare.[4]

The existence and scope of this obligation received considerable attention at recent meetings of the States party to the United Nations Certain Conventional Weapons Convention (CCW). The CCW meetings devoted significant time and resources to examining Lethal Autonomous Weapons Systems (LAWS) and whether there should be a sixth protocol to the Convention preemptively banning such systems, as advocated by some non-governmental organizations (NGOs)[5] and fourteen States.[6] Other States, includ-

1. Convention No. IV Respecting the Laws and Customs of War on Land, Oct. 18, 1907, 36 Stat. 2227, T.S. No. 539; Protocol Additional to the Geneva Conventions of 12 August 1949, and Relating to the Protection of Victims of International Armed Conflicts arts. 35(1)–(2), June 8, 1977, 1125 U.N.T.S. 3 [hereinafter AP I].

2. AP I, *supra* note 1, arts. 35(2), 51(4)(b)–(c).

3. *See* 2 CUSTOMARY INTERNATIONAL HUMANITARIAN LAW 1505–82 (Jean-Marie Henckaerts & Louise Doswald-Beck eds., 2005); *see also* WILLIAM H. BOOTHBY, WEAPONS AND THE LAW OF ARMED CONFLICT 46–73 (2d ed. 2016).

4. AP I, *supra* note 1, art. 36; *see also* U.S. DEPARTMENT OF DEFENSE, OFFICE OF THE GENERAL COUNSEL, LAW OF WAR MANUAL § 6.2 (2016) [hereinafter U.S. DEPARTMENT OF DEFENSE, LAW OF WAR MANUAL].

5. *See, e.g.*, HUMAN RIGHTS WATCH, LOSING HUMANITY: THE CASE AGAINST KILLER ROBOTS (2012).

6. *Ban Support Grows, Process Goes Slow*, CAMPAIGN TO STOP KILLER ROBOTS (Apr. 15, 2016), https://www.stopkillerrobots.org/2016/04/thirdmtg/ (noting that the following countries have publically endorsed a ban: Algeria, Bolivia, Chile, Costa Rica, Cuba, Ecuador, Egypt, Ghana, Holy See, Mexico, Nicaragua, Pakistan, State of Palestine and Zimbabwe).

ing the United Kingdom and the United States, publically declared that existing law is sufficient to regulate LAWS.[7] Indeed, the existing legal obligation to review new weapon systems before they are fielded is a key component of both U.S. and UK policy.

The merits of a ban on autonomous weapons have been well examined in academic law journals, including these pages.[8] Very often, the LAWS debate is stymied by disagreement on what exactly is meant by "autonomous." While this definitional issue is important, especially in the CCW discussions, it can often detract from the substantive issues that should drive this debate. As a result, the UK Development, Concepts and Doctrine Centre (DCDC), itself responsible for Article 36 reviews on behalf of the UK government, invited the Stockton Center for the Study of International Law at the U.S. Naval War College to partner with it to deliver a Forum in October 2016 addressing how lawyers charged with Article 36 reviews might approach their responsibilities in the context of highly automated or autonomous technologies. This "Second International Weapon Review Forum" (the Forum) was attended by a broad mix of State representatives, including weapon reviewing lawyers, academics from science and the law, interested NGOs and the International Committee of the Red Cross (ICRC).[9] It was conducted under the Chatham House Rule.

This article examines the key issues discussed in the Forum, specifically those issues that are likely to arise in the context of legal reviews of autonomous and highly automated weapon systems. It concludes that properly applied, Article 36 is an effective gatekeeper that can and should prevent systems that are incapable of complying with the law from reaching the battle-

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7. *See, e.g.*, United Kingdom of Great Britain and Northern Ireland Statement to the Informal Meeting of Experts on Lethal Autonomous Weapons Systems, Possible Challenges to IHL Due to Increasing Degrees of Autonomy (Apr. 11–15, 2016), https://www.unog.ch/80256EDD006B8954/(httpAssets)/37B0481990BC31DAC1257F940053D2AE/$file/2016_LAWS+MX_ChallengestoIHL_Statements_United+Kingdom.pdf ("The UK's dear position is that IHL is the applicable legal framework for the assessment and use of all weapons systems in armed conflict.").

8. *See, e.g.*, Michael N. Schmitt & Jeffrey S. Thurnher, *"Out of the Loop": Autonomous Weapon Systems and the Law of Armed Conflict*, 4 HARVARD NATIONAL SECURITY JOURNAL 231, 233 (2013).

9. State representatives from Australia, Belgium, Canada, Denmark, Germany, Ireland, the Netherlands, Norway, Sweden, Switzerland, the United Kingdom and the United States attended. NGOs Artide 36 and the Stockholm International Peace Research Institute (SIPRI) also attended.

field (whether autonomous or otherwise). The application of weapon reviews mitigates against a requirement for a preemptive ban. That said, there is a legitimate concern that many States do not take seriously their legal obligation to review new weapons. Further, some States have openly doubted the value of Article 36 reviews in their public positions.[10] Focus on the Article 36 obligation in the LAWS debates at CCW may help change this situation. International fora addressing the conduct of Article 36 reviews also assist States to share best practices and lessons learned, adding strength to a key component of the law of armed conflict.

To consider these issues, this article proceeds as follows. Part II discusses anticipated technologies already in development, which might fall within the gravamen of NGOs' objections to LAWS. Part III assesses the aspects of weapon reviews most pertinent to LAWS, while Part IV examines whether there are, or needs to be, developing norms governing the use of autonomy in weapon systems. Part V concludes.

II. THE FACTS

A. Capability Gaps

Militaries develop weapon systems to fill capability gaps.[11] To better understand issues related to testing and reviewing autonomous technologies, it is important to consider which capability gaps LAWS might fill. This consideration provides a useful context when assessing current and near-future weapon systems. Capability gaps can be identified by examining national defense policy documents or by analyzing current and near-future weapon systems. This Part will do each in turn.

DCDC's *Global Strategic Trends Programme: Global Strategic Trends Fifth Edition – Out to 2045,* while not declarative of UK policy, predicts an increased role for automation and robotics across the field of human activity, including

10. For example, at the 2016 Informal Meeting of Experts on Lethal Autonomous Weapons Systems, China and Brazil observed that Artide 36 reviews might lack efficacy because reviews are unilateral and lack transparency.

11. *See, e.g.*, MOSHE SCHWARTZ, CONGRESSIONAL RESEARCH SERVICE, DEFENSE ACQUISITIONS: HOW DOD ACQUIRES WEAPON SYSTEMS AND RECENT EFFORTS TO REFORM THE PROCESS 4 (2014) (describing the U.S. weapons acquisitions process in which capability gaps are identified and addressed through the acquisitions process).

defense and warfare.[12] This finding is echoed more starkly in the accompanying *Future Operating Environment 2035* (FOE 35), which predicts that many western military capabilities risk being overmatched by technological advancement in the next twenty years, and notes that the proliferation of automation and artificial intelligence is likely to be key to this development. FOE 35 also suggests that some western States initially will be reluctant to rely on these technologies because in the nascent stages of development there may be ethical or reliability concerns.[13] Societal trust and confidence in future defense technology were key themes at the Forum, and this article discusses these issues in Part IV.

The UK Strategic Defence and Security Review (SDSR) expresses the defense policy of the sitting government. The 2015 Review highlights the dangers associated with "long-term shifts in the balance of global economic and military power, increasing competition among states, and the emergence of more powerful non-state actors."[14] It also notes the increasing importance of technology in this shift.

The U.S. counterpart document to the SDSR is the Quadrennial Defense Review (QDR), which echoes many of the same security concerns. The 2014 QDR begins with an acknowledgment that "modern warfare is evolving rapidly" and will lead "to increasingly contested battlespace in the air, sea, [cyberspace] and space domains."[15] Like the SDSR, the QDR notes that future conflicts will likely span the spectrum from "hybrid contingencies against proxy groups" to "high-end conflict against a state power."[16] The QDR also acknowledges that many future adversaries will be technologically sophisticated, which will require the Department of Defense to "sustain priority investments in science, technology, research, and development both within the

12. UK MINISTRY OF DEFENCE, STRATEGIC TRENDS PROGRAMME: GLOBAL STRATEGIC TRENDS – OUT TO 2045 67–73 (5th ed. 2015), https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/348164/20140821_DCDC_GST_5_Web_Secured.pdf.

13. UK MINISTRY OF DEFENCE, STRATEGIC TRENDS PROGRAMME: FUTURE OPERATING ENVIRONMENT 2035 13–20 (1st ed. 2015), https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/484861/20151203-DCDC_FOE_35.pdf.

14. UNITED KINGDOM, NATIONAL SECURITY STRATEGY AND STRATEGIC DEFENCE AND SECURITY REVIEW 2015: A SECURE AND PROSPEROUS UNITED KINGDOM 15 (2015), https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/478936/52309_Cm_9161_NSS_SD_Review_PRINT_only.pdf.

15. U.S. DEPARTMENT OF DEFENSE, QUADRENNIAL DEFENSE REVIEW 2014 § III (2014).

16. *Id.*, § VII.

defense sector and beyond."[17] Regarding autonomy, the QDR specifically notes that "[a]utomated and autonomous systems as well as robotics already have a wide range of commercial, industrial, and military applications—a trend that will likely continue."[18]

There is general agreement in these documents. Both the United Kingdom and the United States are concerned with threats from both non-State actors and States. Likewise, both countries seem acutely aware of the enhanced threat posed by adversaries using advanced technology and asymmetric warfare strategies and both governments have more specifically addressed the importance of autonomy in other policy documents. Nonetheless, as regards LAWS, the two States have declared differing policy positions.

In 2012, the United States published Department of Defense Directive 3000.09.[19] This document provides the most comprehensive policy treatment by any State on the issue of autonomy and war. The directive assigns responsibilities within the Department of Defense for the development of autonomous weapons, provides definitions, establishes the requirement for "appropriate levels of human judgment" over autonomous weapons and creates an acquisition and testing model for autonomous weapons.[20] Of particular note to this article, the directive requires autonomous and semi-autonomous weapons to "go through rigorous hardware and software verification and validation (V&V) and realistic system developmental and operational test and evaluation (T&E)."[21] The directive further requires retesting every time changes are made to the system. Enclosure 3 to the directive specifically addresses the process for conducting legal reviews for autonomous weapons. Notably, the directive requires a legal review before the weapon enters the development process as well as when the system is fielded.[22]

While the two countries' assessments of the future threat are practically identical, the United Kingdom has developed a different policy position on

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17. *Id.*

18. *Id.*; s*ee also* U.S. ARMY, THE U.S. ARMY ROBOTIC AND AUTONOMOUS SYSTEM STRATEGY 1 (2017) ("Pursuing [Robotic Autonomous Systems] allows the Army to improve combat effectiveness of the future eforce.").

19. U.S. Department of Defense, Department of Defense Directive 3000.09, Autonomy in Weapon Systems, Nov. 21, 2012, http://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodd/300009p.pdf [hereinafter Directive 3000.09] (incorporating Change 1, May 8, 2017).

20. *Id.* at 2.

21. *Id.* at 6.

22. *Id.* at 7.

the use of autonomy. In contrast to the United States, the United Kingdom has indicated on several occasions that it is not developing weapons that would be classified as LAWS and that it has no intention to do so. The United Kingdom has also consistently said that weapons will always remain under human control.[23]

The foregoing discussion provides a snapshot of the future operating environment and asks how these assessments might lead to the development of weapon systems with autonomous or highly automated features. Before considering future systems, consider briefly the state of current systems with autonomous features. Globally, the most widely fielded examples are ship-borne Close-in Weapons Systems (CIWS), such as the U.S. Mk15 Phalanx, Dutch Goalkeeper, Russian AK-630 series and the Italian Dardo. In certain modes, set and operated by a human operator, these systems can select and engage incoming targets such as an anti-ship missile without further human intervention. Collectively, forty-five countries have fielded more than 2,000 CIWS systems.[24] Many countries have also fielded similar land-based systems such as the U.S. Patriot air defense system[25] or the Russian Antey S-300VM system.[26]

It is at this point that the LAWS debate can descend into one of definitions rather than substance. Under some approaches, these are not strictly

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23. *See, e.g.*, United Kingdom of Great Britain and Northern Ireland Statement to the Informal Meeting of Experts on Lethal Autonomous Weapons Systems, General Exchange ¶ 3 (Apr. 11–15, 2016), https://www.unog.ch/80256EDD006B8954/(http Assets)/49456EB7B5AC3769C1257F920057D1FE/$file/2016_LAWS+MX_GeneralExchange_Statements_United+Kingdom.pdf ("Furthermore, we have no intention of ever developing systems that could operate without any human control. The UK is committed to ensuring its weapons remain under human control.").

24. Seventy Goalkeeper systems have been fielded by nine countries. *See* JANE'S, WEAPONS: NAVAL, *Goalkeeper* (Jan. 3, 2017), http://janes.ihs.com/Janes/Display/1499735. Nine-hundred Phalanx systems have been fielded by twenty-three countries. *See* JANE'S, WEAPONS: NAVAL, *Mk15 Close-in Weapons System, Phalanx* (June 5, 2017), https://janes.ihs.com/Janes/Display/jnws0269-jnw_. Fifty-two Dardo systems have been fielded by nine countries. *See* JANE'S, C4ISR & MISSION SYSTEMS: MARITIME, *Dardo/NA-30/NA-25*, (May 12, 2017), http://janes.ihs.com/Janes/Display/1505001. Finally, more than 1,150 AK-series systems have been fielded by twenty-four countries. *See* JANE'S, WEAPONS: NAVAL, *30 mm AK-630/AK-630M/AK-306/AK-630M-2 (Duet)* (July 27, 2017), http://janes.ihs.com/Janes/Display/1495990.

25. JANE'S, LAND WARFARE PLATFORMS: ARTILLERY & AIR DEFENSE, *MIM-104 Patriot* (Oct. 17, 2016), https://janes.ihs.com/Janes/Display/1501650.

26. JANE'S, LAND WARFARE PLATFORMS: ARTILLERY & AIR DEFENSE, *S-300V* (Dec. 28, 2016), https://janes.ihs.com/Janes/Display/1501620.

"autonomous" systems at all. For example, the United Kingdom defines autonomy more narrowly than Directive 3000.09 does. The United Kingdom's approach to defining autonomy stems from another DCDC publication, Joint Doctrine Note (JDN) 2/11, which actually concerns unmanned aerial systems. The JDN offers the following definition: "An autonomous system is capable of understanding higher level intent and direction. From this understanding and its perception of its environment, such a system is able to take appropriate action to bring about a desired state. It is capable of deciding a course of action . . . ."[27] In contrast, Directive 3000.09 defines an autonomous weapon system as "[a] weapon system that, once activated, can select and engage targets without further intervention by a human operator."[28]

The United Kingdom would not therefore consider these systems as truly "autonomous." Similarly, the LAWS agenda at CCW focuses on emerging and future, not existing, technologies, indicating no appetite to bring these sorts of systems within any definition of LAWS. Nonetheless, to avoid the definitions issue, important though it is in other contexts, this article adopts a low definitional threshold for "autonomy," and approaches these systems as "first-wave" autonomous weapons. Using this definitional approach, one may consider "second-wave" systems to include recently fielded systems such as the Israeli Harpy counter-radar system[29] and the British Brimstone anti-tank missile.[30] Like the first-wave weapons, second-wave weapons are designed to target objectives that are military by nature. Unlike first-wave systems, second-wave systems are not point defense systems that are fixed in a single location and designed to protect a particular object. Second-wave systems are exemplified by the spate of unmanned combat aerial vehicles currently under development such as the Dassault Neuron, [31] BAE

27. UK MINISTRY OF DEFENCE, DEVELOPMENT, CONCEPTS AND DOCTRINE CENTRE, JOINT DOCTRINE NOTE 2/11: THE UK APPROACH TO UNMANNED AIRCRAFT SYSTEMS 2-3 (2011).

28. Directive 3000.09, *supra* note 19, at 13.

29. JANE'S, UNMANNED AERIAL VEHICLES AND TARGETS, *IAI Harpy* (Feb. 14, 2017), https://janes.ihs.com/Janes/Display/1317898.

30. JANE'S, AIR-LAUNCHED WEAPONS, *Brimstone (Legacy)* Apr. 28, 2016), https://janes.ihs.com/Janes/Display/1307308.

31. DASSAULT AVIATION: INTRODUCTION, http://www.dassault-aviation.com/en/defense/neuron/introduction/ (last visited Aug. 21, 2017).

Systems Taranis[32] and the Northrop Grumman X-47.[33] These systems all have autonomous navigation capabilities and could be configured to carry armed payloads. Similar developments can be seen in rotary-wing systems such as the autonomous Blackhawk helicopter,[34] Lockheed Martin K-Max[35] and Northrop Grumman Fire Scout.[36]

Several ground-based next generation systems are currently in development including the Guardium class of ground vehicles, which can autonomously patrol an area[37] or navigate to a given location.[38] The Guardium vehicles have been in service with the Israeli Defense Force since 2012,[39] and have recently been replaced with the Segev vehicles, which are automated to an even greater degree.[40] In 2011, Lockheed Martin began operationally field testing a similar system dubbed the Squad Mission Support System (SMSS), which is designed to "follow the leader" autonomously.[41] These developments keep with the U.S. Army Robotics and Autonomous Systems (RAS) strategy, which presents five objectives for RAS: increasing situational awareness, lightening the soldier's physical and cognitive workloads, sustaining the

32. BAE SYSTEMS, PRODUCTS: TARANIS, http://www.baesystems.com/en/product/taranis (last visited Aug. 21, 2017).

33. NORTHROP GRUMMAN, X-47B UCAS: UNMANNED COMBAT AIR SYSTEM (2015), http://www.northropgrumman.com/Capabilities/X47BUCAS/Documents/UCAS-D_Data_Sheet.pdf.

34. Thierry Dubois, *Sikorsky to Add Black Hawk to Autonomy Program*, AINONLINE (June 11, 2015, 8:50 AM), http://www.ainonline.com/aviation-news/defense/2015-06-11/sikorsky-add-black-hawk-autonomy-program.

35. LOCKHEED MARTIN, K-MAX, http://www.lockheedmartin.com/us/products/kmax.html (last visited Aug. 21, 2017).

36. NORTHROP GRUMMAN, CAPABILITIES: FIRE SCOUT, http://www.northropgrumman.com/Capabilities/FireScout/Pages/default.aspx?utm_source=PrintAd&utm_medium=Redirect&utm_campaign=FireScout+Redirect (last visited Aug. 21, 2017).

37. JANE'S, LAND WARFARE PLATFORMS: LOGISTICS, SUPPORT & UNMANNED, *Guardium Mk III* (May 18, 2016), http://janes.ihs.com/Janes/Display/1706382.

38. JANE'S, LAND WARFARE PLATFORMS: LOGISTICS, SUPPORT & UNMANNED, *Guardium Mk II* (May 18, 2016), http://janes.ihs.com/Janes/Display/1495489.

39. JANE'S, LAND WARFARE PLATFORMS: LOGISTICS, SUPPORT & UNMANNED, *Guardium Mk III*, *supra* note 37.

40. Yaakov Lappin, *Israel's New Segev UGVs to Become "Fully Autonomous,"* JANE'S 360 (Dec. 1, 2016), http://www.janes.com/artide/65900/israel-s-new-segev-ugvs-to-become-fully-autonomous.

41. LOCKHEED MARTIN, SMSS (SQUAD MISSION SUPPORT SYSTEM), http://www.lockheedmartin.com/us/products/smss.html (last visited Aug. 21, 2017).

force with increased efficiency, facilitating movement and maneuver and protecting the force.[42]

Water-based autonomous systems evidence similar developments. The U.S. Department of the Navy sees autonomy as a core technology to their future success.[43] There are, for example, numerous autonomous countermine vehicles under development, including the SeaFox/SeaWolf,[44] SeaOtter,[45] Knifefish,[46] REMUS[47] and Pluto Gigas.[48] Other sea-based technologies include autonomous systems delivered by airborne or seabed delivery systems.[49]

The "third-wave" of autonomy-enabled weapon systems will be characterized by increased autonomy and, most critically, artificial intelligence enabled systems. In the 2013 Unmanned Systems Roadmap, the U.S. Department of Defense summarizes the transition:

> The future of autonomous systems is characterized as a movement beyond autonomous mission execution to autonomous mission performance. The difference between execution and performance is that the former simply executes a preprogrammed plan whereas performance is associated with

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42. U.S. ARMY, *supra* note 18, at 1–2.

43. *See, e.g.*, OFFICE OF THE SECRETARY OF THE NAVY, NAVAL RESEARCH ADVISORY COMMITTEE, NAVAL RESEARCH ADVISORY COMMITTEE REPORT: HOW AUTONOMY CAN TRANSFORM NAVAL OPERATIONS 9 (2012), https://www.nrac.navy.mil/docs/NRAC_Final_Report-Autonomy_NOV2012.pdf ("The addition of autonomous systems may be the only solution for addressing the evolving strategic A2AD challenge to the Fleet."); U.S. DEPARTMENT OF THE NAVY, THE NAVY UNMANNED UNDERSEA VEHICLE (UUV) MASTERPLAN 57 (2004), http://www.navy.mil/navydata/technology/uuvmp.pdf [hereinafter THE NAVY UUV MASTERPLAN] ("Autonomy issues are key to all the UUV [underwater unmanned vehides] missions.").

44. Willi Hornfeld, *SeaFox IQ/SeaWolf: New Mini and Midi AUVs for Security and Inspection*, http://auvac.org/uploads/configuration_spec_sheets/Hornfeld-SeaFox%20IQSeaWolf. pdf (last visited Aug. 21, 2017).

45. ATLAS MARIDAN SEAOTTER: AUTONOMOUS UNDERWATER VEHICLE (AUV), http://auvac.org/uploads/configuration_spec_sheets/Atlas%20sea%20otter.pdf (last visited Aug. 21, 2017).

46. GENERAL DYNAMICS MISSION SYSTEMS, KNIFEFISH UNMANNED UNDERSEA VEHICLE, https://gdmissionsystems.com/maritime-strategic/submarine-systems/knifefish-unmanned-undersea-vehide/ (last visited Aug. 21, 2017).

47. JANE'S, UNMANNED MARITIME VEHICLES AND SYSTEMS, *Remus 100* (Dec. 1, 2016), http://janes.ihs.com/Janes/Display/juws2192-jumv.

48. IDROBOTICA, PLUTO GIGAS, http://www.idrobotica.com/pluto-gigas.php (last visited Aug. 21, 2017).

49. THE NAVY UUV MASTERPLAN, *supra* note 43, at 63.

mission outcomes that can vary even during a mission and require deviation from preprogrammed tasks.[50]

B. The Technology of Autonomy

Artificial intelligence is fundamental to achieving higher levels of autonomy. Given the likely centrality of artificial intelligence in future warfare, it is worthwhile to consider the technology. Within the broader field of artificial intelligence, deep learning systems such as convolutional neural networks are perhaps the most relevant to near-future military capability development. As discussed below, a neural network differs from a traditional computer system in that it is comprised of millions of nodes arrayed in layers.[51] This allows for vastly increased processing powers in certain applications.[52] To use but one example, Google recently converted Google Translate to use a convolutional neural network. Instantly, the translation service reduced translation errors by an average of 60%.[53] The technology of neural networks is discussed below, but it is not hyperbole to suggest that potential military applications are virtually unlimited. Examples include systems that could identify enemy personnel, incredibly precise weapon systems, systems that could predict hostile actions, robots that could navigate complex terrain and systems that could map out enemy networks. Given the likely centrality of artificial intelligence in future warfare, it is worthwhile to consider the technology.

The traditional approach to artificial intelligence, termed symbolic artificial intelligence, works on the premise that the system is provided data that it then uses to make decisions.[54] For example, to enable a UAV to navigate autonomously, engineers would program a UAV with maps together with a large number of rules for flying (e.g., what altitude to fly, how to avoid other

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50. U.S. DEPARTMENT OF DEFENSE, UNMANNED SYSTEMS INTEGRATED ROADMAP FY2013–2038 66–67 (2013), https://www.defense.gov/Portals/1/Documents/pubs/DOD-USRM-2013.pdf.

51. Larry Hardesty, *Explained: Neural Networks*, MIT NEWS (Apr. 14, 2017), http://news.mit.edu/2017/explained-neural-networks-deep-learning-0414.

52. *Id.*

53. Yonghui Wu et al., *Google's Neural Machine Translation System: Bridging the Gap between Human and Machine Translation*, CORNELL UNIVERSITY LIBRARY, COMPUTER SCIENCE: COMPUTATION AND LANGUAGE (Oct. 8, 2016), https://arxiv.org/pdf/1609.08144v2.pdf.

54. *See generally* Vasant Honavar, *Symbolic Artificial Intelligence and Numeric Artificial Neural Networks: Towards a Resolution of the Dichotomy*, *in* COMPUTATIONAL ARCHITECTURES INTEGRATING NEURAL AND SYMBOLIC PROCESSES: A PERSPECTIVE ON THE STATE OF THE ART 351 (Ron Sun & Lawrence A. Bookman eds., 1995).

aircraft, how to ensure sovereign airspace is not violated and what to do when various contingencies are encountered). This approach works well in systems where there are clear rules.[55] Where the rules are less clear or there are many exceptions, this programing approach is less effective.

Artificial neural networks offer a second approach to artificial intelligence, which addresses the deficiencies in the symbolic approach by developing systems that learn based on data rather than rules. A neural network learns by being provided data from which the system will generalize conclusions and develop rules.[56] The approach mimics the function of a human brain. Where a human brain consists of neurons firing electrical charges to one another, an artificial neural network utilizes nodes, arranged in layers, which transfer information from one node to another. Thus, nodes in the network receive either input information from the user (e.g., an image captured from a reconnaissance aircraft) or input from another node.

In a simplified example, imagine a neural network that is designed to identify enemy tanks. The network will consist of multiple layers, with each layer consisting of several nodes.[57] The first layer of nodes identifies the existence of individual pixels, while subsequent layers identify outlines of objects, motifs and parts. The final layer identifies the object.[58]

For the network to function properly, the network must first be trained. Training can be supervised or unsupervised. In a supervised training paradigm—the most common method of training—the system is provided both input data and the desired outcome. In the example above, the system would be provided an image of a tank and the desired output of "tank." At the beginning of the training, the system will not correctly identify the image as a tank because the system has not yet learned what a tank is. The system

55. Gideon Lewis-Kraus, *The Great A.I. Awakening,* NEW YORK TIMES, Dec. 14, 2016, (Magazine), https://www.nytimes.com/2016/12/14/magazine/the-great-ai-awakening.html.

56. DAVID KRIESEL, A BRIEF INTRODUCTION TO NEURAL NETWORKS 7 (2007), http://www.dkriesel.com/_media/science/neuronalenetze-en-zeta2-2col-dkriesel.com.pdf.

57. Yann LeCun, Center for Data Science & Courant Institute, New York University & Marc'Aurelio Ranzato, Google, International Machine Learning Conference, Deep Learning Tutorial (June 16, 2013), http://www.cs.nyu.edu/~yann/talks/lecun-ranzato-icml2013.pdf.

58. *Id.*

learns through a technique called backward propagation of errors (or backpropagation).[59] When the system provides an incorrect output—say, misidentifying a cat as a tank—an error value is assigned that reflects the divergence between the correct and incorrect answer.[60] The error value is then backpropagated through the neural network, and the network then determines *on its own* how the various connections between nodes should be weighed to correctly output "tank" when shown an image of a tank. In a deep learning system, there may be hundreds of millions of nodes and weighted values. The system will continue to self-adjust weighted values until the desired result is met. This process is iterative and can take many hundreds of thousands of iterations.

III. LEGAL QUESTIONS AND POLICY CONSIDERATIONS

All representatives at the Forum agreed that Article 36 of Additional Protocol I represented a binding obligation on States party to carry out a review of new weapons, means and methods of warfare before their use during an armed conflict.[61] Before turning to the substance of Article 36, it is worth noting that the Forum discussed the problem of widespread non-observance of the article. Most States party to Additional Protocol I do not complete weapon reviews, or they do not publically acknowledge doing so. Some States party are openly skeptical of the requirement.[62] Nonetheless, there has been little protest from States that rigorously comply with Article 36 obligations. This quietude undoubtedly undermines the force and effectiveness of Article 36. The authors are cautiously optimistic that the light the LAWS

59. Jürgen Schmidhuber, *Deep Learning in Neural Networks: An Overview*, CORNELL UNIVERSITY LIBRARY, COMPUTER SCIENCE: NEURAL AND EVOLUTIONARY COMPUTING (Oct. 8, 2014), https://arxiv.org/pdf/1404.7828.pdf.

60. *See* Yann LeCun, Yoshua Bengio & Geoffrey Hinton, *Deep Learning*, NATURE, May 28, 2015, at 436.

61. On these issues, see generally COMMENTARY ON THE ADDITIONAL PROTOCOLS OF 8 JUNE 1977 TO THE GENEVA CONVENTIONS OF 12 AUGUST 1949, ¶¶ 1471–74 (Yves Sandoz, Christophe Swinarski & Bruno Zimmermann eds., 1987) [hereinafter COMMENTARY ON THE ADDITIONAL PROTOCOLS]; *see also* U.S. DEPARTMENT OF DEFENSE, LAW OF WAR MANUAL, *supra* note 4 (explaining the U.S. policy requirements for the legal review of new weapons).

62. *See generally* Vincent Boulanin, *Implementing Article 36 Weapon Reviews in the Light of Increasing Autonomy in Weapon Systems*, 2015/1 SIPRI INSIGHTS ON PEACE AND SECURITY (2015), https://www.sipri.org/sites/default/files/files/insight/SIPRIInsight1501.pdf.

debate has shone on Article 36 will prompt States to pay greater heed to the obligation to carry out reviews.

As discussed above, Article 36 creates a binding obligation on States party to Additional Protocol I to complete weapon reviews on new weapons and new means and methods of warfare before use in an armed conflict. Article 36 states:

> In the study, development, acquisition or adoption of a new weapon, means or method of warfare, a High Contracting Party is under an obligation to determine whether its employment would, in some or all circumstances, be prohibited by this Protocol or by any other rule of international law applicable to the High Contracting Party.[63]

Many aspects of Article 36's language and drafting are of interest, but there is not space in this article to assess the broader implications of, for example, the use of the phrase "study development, acquisition or adoption," or what precisely falls within the scope of a "weapon, means or method of warfare."[64] Similarly, since all States represented at the Forum were either parties to the Protocol or had, as a matter of policy, adopted their own weapon review procedures, there was little need to examine whether there is any customary law requirement to carry out weapon reviews. However, four aspects of the conduct of reviews raise issues in the context of LAWS and will be addressed in this Part. These aspects are (a) the requirement for "newness" and the trigger for a weapon review; (b) the substantive questions required to be addressed during a review; (c) relevant factual considerations and (d) how testing and evaluation inform a review.

A. What is "New"?

Article 36 requires reviews of "new" weapons or means or methods of warfare.[65] This formulation is slightly different from that used by the United States, which requires—as a matter of policy—"the legal review of the intended acquisition or procurement of weapons or weapon systems."[66] The ICRC Commentary to the Additional Protocols seems to adopt a position that emphasizes both the "new" criterion of the rule and the focus of the

63. AP I, *supra* note 1, art. 36.
64. COMMENTARY ON THE ADDITIONAL PROTOCOLS, *supra* note 61, at ¶ 1473.
65. AP I, *supra* note 1.
66. U.S. DEPARTMENT OF DEFENSE, LAW OF WAR MANUAL, *supra* note 4, § 6.2.

United States on the acquisition of the weapon. The Commentary states: "The High Contracting Parties are obliged to determine the legality or illegality of the use of any new weapon introduced into their armed forces."[67] Neither the commentary nor other ICRC publications discuss what constitutes "new" for Article 36.

The United Kingdom interprets "new" to refer both to weapons that are new to the inventory and to existing weapons that have been modified or whose nature or use has changed.[68] Most participants at the forum agreed that Article 36 extends to both categories of "new" weapons. This raises the question of how much change in the weapon's inherent character or use is required to trigger a new review. Such questions are particularly relevant to artificial intelligence and deep learning systems, as discussed previously.

A precursor to Article 36, the 1868 St. Petersburg Declaration, provides useful insight on this issue, as the final clause of the Declaration states that

> The Contracting or Acceding Parties reserve to themselves to come hereafter to an understanding whenever a precise proposition shall be drawn up in view of future improvements which science may effect in the armament of troops, in order to maintain the principles which they have established, and to conciliate the necessities of war with the laws of humanity.[69]

This language presupposes that technical "improvements" may be made to weapons that would trigger the need to reconsider the legality of the weapon. A weapon can be changed in one of two ways: changes to the way a weapon is used, or changes to the weapon itself.

Consider first changes to the *use* of a weapon. Article 36 and the U.S. Department of Defense regulation require that a review be undertaken based on the normal intended use of the weapon.[70] Accordingly, weapon review

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67. COMMENTARY ON THE ADDITIONAL PROTOCOLS, *supra* note 61, ¶ 1479.

68. UK MINISTRY OF DEFENCE, DEVELOPMENT, CONCEPTS AND DOCTRINE CENTRE, UK WEAPON REVIEWS (2016), https://www.gov.uk/government/publications/uk-weapon-reviews [hereinafter UK MINISTRY OF DEFENCE, UK WEAPON REVIEWS].

69. Declaration Renouncing the Use, in Time of War, of Explosive Projectiles Under 400 Grammes Weight, Nov. 29/Dec. 11, 1868, 138 Consol. T.S. 297, 18 MARTENS NOUVEAU RECUEIL (ser. 1), 474.

70. International Committee of the Red Cross, *A Guide to the Legal Review of New Weapons, Means and Methods of Warfare: Measures to Implement Article 36 of Additional Protocol I of 1977*, 88 INTERNATIONAL REVIEW OF THE RED CROSS 931 (2006); U.S. DEPARTMENT OF DEFENSE, LAW OF WAR MANUAL, *supra* note 4, ¶ 6.2.2. (noting that the United States considers the "weapon's intended use" to determine whether the weapon is "calculated to cause superfluous injury").

lawyers must review weapon systems with a view to the uses that their government intends to put them.[71] Presumably, where a weapon is to be used in a way not envisioned by the review, this would trigger a new review. In the United Kingdom, this normal use is described in a "Concept of Employment" or "Concept of Use," which is submitted with the business case seeking financial approval for a system's procurement. Where the normal use of a weapon or weapon system changes during its operational lifetime, this is a trigger for a new review.[72]

Consider now changes to the weapon itself. This category of change is especially pertinent in the context of weapon systems that employ machine learning. By way of example, consider the Stinger missile, a portable anti-aircraft system that uses an infrared sensor to home in on a target.[73] What if the missile's software were upgraded to a neural network that would allow the missile to identify targets more accurately? Is this a new weapon that would trigger a weapon review, or is this simply a software upgrade but the same weapon system? What if the neural network is continuously learning? Does the system at some point become a "new" system because it has learned so much, or because it changes the manner in which it operates?

It seems self-evident that technical changes to an existing weapon could have the effect of creating a new weapon. For example, the Joint Direct Attack Munition (JDAM) is a guidance package that is installed on unguided bombs, thereby converting "dumb bombs" into satellite-guided "smart" munitions.[74] As with a neural network algorithm, a guidance package standing alone is not a weapon. The unguided bomb that the JDAM is attached to is a weapon. When the JDAM is installed on the unguided bomb, an entirely new weapon has been created, which must be considered "new" for weapon review purposes. This conclusion seems uncontroversial. That a new weapon is not created when the unguided bomb undergoes a *de minimis* change, such as being repainted, is equally uncontroversial. Where, then, does one draw the line?

The ICRC argues that Article 36 extends to cover "an existing weapon that is modified in a way that alters its function, or a weapon that has already

71. COMMENTARY ON THE ADDITIONAL PROTOCOLS, *supra* note 61, ¶ 1466.

72. UK MINISTRY OF DEFENCE, UK WEAPON REVIEWS.

73. RAYTHEON, STINGER WEAPON SYSTEM, http://www.raytheon.com/capabilities/products/stinger/ (last visited Aug. 21, 2017).

74. BOEING, WEAPONS, http://www.boeing.com/defense/weapons/ (last visited Aug. 21, 2017).

passed a legal review but that is subsequently modified."[75] William Boothby echoes this perspective, observing that a weapon should be re-reviewed when "the weapon has been the subject of an upgrade or other amendment that changes its combat performance."[76] Other commentators conclude that Article 36 extends to weapons "subsequently modified after an initial review."[77] Further, one commentator finds that "significant changes in anticipated use" would trigger a new review.[78] The *Tallinn Manual* uses this same language, concluding that "significant changes" to a weapon would trigger a new review under Article 36, but that "[m]inor changes that do not affect [the weapon's] operational effects . . . would not trigger the requirement for a subsequent review."[79]

The idea that "significant" or "material" changes to a weapon triggers a legal requirement for a new review finds some support in State practice. The UK weapon review policy guidance notes that weapons subject to review can be entirely new systems or systems that originate after "modifications to existing systems."[80] The document expressly states "any change in a systems' use or capability" will subject the system "to further review."[81] Similarly, the U.S. Air Force regulation governing weapon reviews requires reviews of "all weapons being developed, bought, built, *modified* or otherwise being acquired by the Air Force . . . ."[82] Likewise, the U.S. Army requires the originator of the request for a weapon review to notify the reviewing authority when changes are made to a weapon system that "would modify the injury or dam-

75. International Committee of the Red Cross, *supra* note 70.

76. BOOTHBY, *supra* note 3, at 355.

77. Isabelle Daoust, Robin Coupland & Rikke Ishoey, *New Wars, New Weapons? The Obligation of States to Assess the Legality of Means and Methods of Warfare*, 84 INTERNATIONAL REVIEW OF THE RED CROSS 345, 352 (2002).

78. James D. Fry, *Contextualized Legal Reviews for the Methods and Means of Warfare: Cave Combat and International Humanitarian Law*, 44 COLUMBIA JOURNAL OF TRANSNATIONAL LAW 453, 471 (2006).

79. TALLINN MANUAL ON THE INTERNATIONAL LAW APPLICABLE TO CYBER WARFARE r. 48, at ¶ 8 (Michael N. Schmitt ed., 2013).

80. UK MINISTRY OF DEFENCE, UK WEAPON REVIEWS.

81. *Id.*

82. U.S. Department of the Air Force, Air Force Instruction 51-402, Legal Reviews of Weapons and Cyber Capabilities, July 27, 2011, ¶ 1, http://nsarchive2.gwu.edu//NSAEBB/NSAEBB424/docs/Cyber-053.pdf (emphasis added).

age producing mechanisms of the weapon or weapon system or their intended use in armed conflict."[83] Finally, the German weapon review process applies to "newly developed [or] significantly modified" weapons.[84]

The authors have reached the position that changes or modifications to a weapon would trigger a new review when the changes satisfy a two-part test: (1) the changes cause the weapon to operate in a manner not contemplated by the first weapon review; and (2) the changes potentially affect the ability to use the weapon in compliance with applicable legal standards. The second prong of this formulation would exclude changes that cause different performance than expected but bear no relation to the legal obligations of the weapon. For instance, an autonomous air system might learn that it is more fuel efficient to fly at 10,000 feet, rather than 9,500 feet. This change is causing the system to perform in a manner unexpected at the time of the review, but nonetheless should not trigger a new review, assuming the altitude change did not affect its compliance with legal rules. Conversely, this formulation would include modifications that increase or decrease the ability of the system to act with, or be employed with, distinction, or modifications that cause the weapon to have more or different kinetic effect, thus changing the proportionality calculus.

Having decided upon a threshold, how does one apply it to continuously learning systems? The obvious solution would be to restrict learning to controlled environments. This might be a short-term solution, but the potential military advantages of a system that can learn in the operational environment will likely be too great to ignore. Recognizing the inherent difficulties with learning systems, the U.S. Defense Science Board recommended that testing and evaluation of such systems occur across the entire life cycle of the system.[85] Even where a system is trained entirely in a controlled environment, however, the possibility remains that different individual systems will learn slightly differently. Consider the Stinger example. The neural network powering each Stinger would have to be trained. The network would self-adjust to the desired outcome, but each network would adjust differently from sister networks on other missiles even using the same training sets. Thus, if the

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83. U.S. Department of the Army, Army Regulation 27-53, Review of Legality of Weapons Under International Law, Jan. 1, 1979, ¶ 6(a)(3), https://fas.org/irp/doddir/army/ar27-53.pdf.

84. Federal Republic of Germany, Federal Ministry of Defense, Joint Service Regulation A-2146/1, June 13, 2106, ¶ 3.

85. U.S. DEPARTMENT OF DEFENSE, DEFENSE SCIENCE BOARD, SUMMER STUDY ON AUTONOMY 33 (2016) [hereinafter SUMMER STUDY ON AUTONOMY].

manufacturer produced 100 Stingers, and each was trained in the same manner, it is still conceivable that the individual missiles will have different aptitudes. If the systems learn *in situ*, these concerns become more acute.

The Forum grappled with this issue at length. It is easy enough to posit that a system must be re-reviewed when a relevant change is made. However, when a system learns continuously, and the outcomes of that learning are not predictable, it is hard, if not impossible, to state at what point it must be re-reviewed.

Despite this challenge, the problem is not intractable. In order for the weapon or system to pass its initial review, most agreed that it would be critical to understand what stimuli the system would be exposed to, and how this would affect the system's learning. Otherwise, the system would risk being too unpredictable for a weapon reviewing lawyer to be satisfied that its intended use (or range of uses) was lawful.[86] This forward-looking review of what the machine might learn and in what circumstances could be supplemented by a program of re-reviews, tailored to the system, which might be periodic (time-based) or substantive (after each operational or exercise use) as discussed between the system engineers, the user community and the legal reviewer.

B. Questions Addressed by the Review

The specific laws of armed conflict to be considered during a weapon review are relatively settled.[87] If a weapon review is to comply with Article 36, it is widely accepted that the following assessments must be considered:

1. Is the weapon, means or method of warfare (or its use, possession, development) prohibited by a specific treaty or customary law provision?[88]
2. Is the weapon, means or method of warfare inherently of a nature to cause superfluous injury or unnecessary suffering in its normal or intended use?[89]

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86. *See infra* Part IV.B (discussing "authorized power").

87. BOOTHBY, *supra* note 3, at 342–49.

88. *See, e.g.*, 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, Oct. 10, 1980, 1342 U.N.T.S. 137; Protocol on Blinding Laser Weapons, Oct. 13, 1995, 1380 U.N.T.S. 370.

89. AP I, *supra* note 1, art. 35(2).

3. Is the weapon, means or method of warfare inherently of a nature to be indiscriminate, in its normal or intended use?[90]
4. Is the weapon, means or method of warfare intended, or might be expected, to cause widespread, long-term and severe damage to the natural environment?[91]

Commentators have suggested additional considerations. For example, William Boothby suggests that a fifth question ought to be asked: Are there any possible or likely developments in the law that will render the weapon, means or method of warfare unlawful during its anticipated lifetime?[92] Moreover, the ICRC suggests consideration of proportionality and precautions in attack as well as an evaluation under the Martens Clause.[93]

At the Forum, there seemed to be general agreement as to the four criteria articulated above. The fifth consideration suggested by Boothby also garnered significant support and is reflected in the UK approach. There was notable debate regarding the ICRC suggestions. Contrary to the ICRC position, some at the Forum took the position that proportionality is always a question for the operational commander in the circumstances of a particular attack, not a general question for a weapon review.[94] Similarly, some took the view that separate review under the Martens Clause is not warranted, perhaps because, as Dinstein notes, "general revulsion in the face of a particular conduct during hostilities (even if it goes beyond habitual fluctuations of public opinion) does not create 'an independent legal criterion regulating weaponry' or methods of warfare."[95] This view keeps with the U.S. position

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90. *Id.*, art. 51(4)(b)–(c).

91. *Id.*, art. 35(3). *See also* Convention on the Prohibition of Military or Any Hostile Use of Environmental Modification Techniques, May 18, 1977, 31 U.S.T. 333, 1108 U.N.T.S. 151.

92. BOOTHBY, *supra* note 3, at 348.

93. International Committee of the Red Cross, *supra* note 70, at 945. For the Martens Clause, see the Preamble to 1907 Hague Convention No. IV, which states:

> Until a more complete code of the laws of war has been issued, the high contracting Parties deem it expedient to declare that, in cases not included in the Regulations adopted by them, the inhabitants and the belligerents remain under the protection and the rule of the principles of the law of nations, as they result from the laws of humanity, and the dictates of the public conscience.

Convention No. IV Respecting the Laws and Customs of War on Land, Oct. 18, 1907, 36 Stat. 2227, T.S. No. 539.

94. BOOTHBY, *supra* note 3.

95. YORAM DINSTEIN, CONDUCT OF HOSTILITIES 14 (3d ed. 2016) (citing P.A. Robblee, *The Legitimacy of Modern Conventional Weaponry*, 71 MILITARY LAW REVIEW 95, 125 (1976)).

on the applicability of the Martens Clause.[96] The United Kingdom, however, does specifically address the Martens Clause in its weapon reviews.

Many agreed that considerations of targeting law and precautions in attack were questions for the operational commander and his or her legal and other advisers to consider in the particular circumstances of an operation or attack. For example, the application of the considerations in Article 57 can only properly be made on the facts of a specific scenario and cannot be considered in isolation when a weapon is procured. However, the case was made that for autonomous weapons or weapons with a high degree of autonomy, the concept of employment for the weapon system may call for issues of targeting and precautions in attack to be called forward to the weapon review stage.[97] For example, an anti-aircraft defense (ADA) system may be pre-authorized to engage enemy aircraft within given parameters. As opposed to a conventional ADA system, elements of the engagement decision, such as the decision regarding the specific target to engage, are pre-loaded in a weapon. It was argued by some that with such a system the weapon review should consider factors such as proportionality and precautions in attack.

This argument was not universally accepted. Some considered that as long as the system was *capable* of lawful use, then the decision as to whether to field it and employ it was always a "choice of means" question under Article 57 and therefore one for the commander, cognizant of the weapon's authorized engagement parameters, the effect of its round and other considerations. On this analysis, it was not a question for a weapon review. Arguably, both approaches lead to the same substantive result; namely, that these important legal issues are properly addressed before systems are fielded.

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96. U.S. Department of State, U.S. Mission to the United Nations and Other International Organization in Geneva, U.S. Delegation Statement on Overarching Issues, CCW Informal Meeting of Experts on Lethal Autonomous Weapons Systems (LAWS) (Apr. 16, 2015), https://geneva.usmission.gov/2015/04/16/ccw-informal-meeting-of-experts-on-lethal-autonomous-weapons-systems-laws/ ("As an initial matter, the Martens Clause is not a rule of international law that prohibits any particular weapon, much less a weapon that does not currently exist. Rather, it is recognition that when no specific rule applies, the customary principles of IHL govern conduct during armed conflict.").

97. *See, e.g.*, Kimberley Trapp, Precautionary Measures, 'Feasibility, & LAWS, Presentation to the Informal Meeting of Experts on Lethal Autonomous Weapons Systems (Apr. 11–15, 2016), https://www.unog.ch/80256EDD006B8954/ (httpAssets)/F8A5FD4EB812F8BAC1257F94004245CF/$file/CCW_LAWS+MX+Presentations_ChallengestoIHL_Kimberley+Trapp.pdf.

C. Relevant Considerations

Specific considerations will inform each question addressed in a legal review. Accordingly, a weapon system's reliability in performing as intended in its concept of employment will inform a great many of the substantive legal considerations. Consider the relatively humble 5.56mm rifle bullet. It will usually be designed to be propelled, rotating at high velocity, in a straight line from the infantryman's rifle to the desired target. In *n* % of usages, it will perform as intended. However, in 100-*n* % of usages, it will malfunction in some way, perhaps by "tumbling" in the air, causing it to miss its target or inflict a wound upon the intended target more serious than it would have been had the round not tumbled. Or, it may fail to reach its target at all.

These issues must all be considered by the weapon reviewing lawyer, who must ask how reliable any given weapon system has been in testing.[98] What is the effect of any malfunction? Does malfunction affect the system's ability to comply with, say, the rule of distinction or the rule prohibiting unnecessary suffering or superfluous injury? If not, then the weapon is simply less effective rather than less compliant: a problem for the procurement authority and the end operational user, perhaps, but not so much a concern for the reviewing lawyer. But, where reliability effects legal compliance, the reviewing lawyer must ask to what extent the law permits malfunction. The representatives at the Forum were clear that no weapon system (or any system) operates at 100% effectiveness. Accordingly, the law cannot require 100%. But, is there an acceptable reliability threshold? And, if so, what is that threshold? Is it 95%? 50%?

The authors sensed agreement among many at the Forum that the acceptable reliability threshold will depend upon the effect of failure on a system's ability to comply with any given rule. It is impossible to set a benchmark reliability figure that will apply to all systems subject to review, but the performance of old systems that the new capability is designed to replace might be indicative. Still, they may not be indicative if a new system brings with it a marked change to military effectiveness in comparison to the system it replaces. In essence, this is a contextual legal judgment, grounded in reasonableness or due diligence.[99] In reaching this judgment, the legal reviewer

98. *See generally supra* Part III.

99. Of note, in some circumstances, "due diligence" obligations may be more stringent on States with greater resources to allocate to the problem. International law is otherwise silent on how States use their resources to meet competing demands. *See* Trapp, *supra* note 97, at 5–7.

will have to assess what level of effort procurement teams have invested in determining reliability. What trials have been done, and in what circumstances? Were they suitably realistic? How reliable are the conclusions the procurement team has reached as to the system's failure rate, and the effects of failure? Do these considerations provide a sufficiently robust basis on which to ground legal advice? The answer will depend on the circumstances.

The 5.56mm rifle round has been deliberately chosen to demonstrate that these apparently difficult questions arise even in the context of relatively uncontroversial and non-complex weapons or weapon systems. For weapon systems involving complex technology, including high degrees of autonomy, automation or machine learning, these questions are especially important and empirically harder to answer. While a reviewing lawyer need not understand the technology in intricate detail, he or she will need to have a sufficient grasp of the technology to understand its capabilities, limitations and reliability. Many at the Forum felt that sheer complexity alone was not a reason a system should fail a weapon review. It was equally agreed that a system that performed unpredictably would fail a weapon review if the reviewing lawyer could not be satisfied that the range of possible outcomes from a system's use was lawful. This lack of predictability might be because of unacceptable system failure, or because the system lacked sufficient built-in controls by design. An example of the former would be the system that erroneously identified cats as tanks, whereas an example of the latter would be a system that was permitted, because of less than stringent engineering standards, to adopt unlawful behaviors in response to certain stimuli. For example, a system that was allowed to learn that it could evade detection and destruction by acting perfidiously would be unlawful.

The Forum also considered to what extent enemy action in response to a system's employment was a relevant consideration in a weapon review. This is particularly pertinent in the context of systems dependent on autonomy or artificial intelligence, as critics have suggested that these systems would be prone to hacking, or that it would be easy to subvert or mislead a deep learning system to behave unlawfully.[100] Some participants suggested that enemy action to counter a system should be considered in a review. While this might clearly be expedient, is it a legal requirement? Participants expressed a range of views at the Forum, but the view that comes closest to representing consensus is that only likely or inevitable enemy action must be

100. *See, e.g.*, John Markoff, *Report Cites Dangers of Autonomous Weapons*, NEW YORK TIMES, Feb. 28, 2016, https://www.nytimes.com/2016/02/29/technology/report-cites-dangers-of-autonomous-weapons.html.

contemplated, as the high likelihood of these responses means they should properly be considered as part of the context in which the system will be used. Second, and analogous to the position reached on malfunction, the weapon review needs to focus on the effect of enemy action. Does it affect the system's ability to comply with the law, or does it merely make the system less operationally effective?

D. Testing and Evaluation

The newness and complexity of these technologies raise significant questions concerning how such technologies are tested, and the way in which that testing and evaluation (T&E) informs the legal review. The most detailed consideration of autonomy in the context of weapon testing and weapon reviews comes in three U.S. Department of Defense documents: two unmanned systems "roadmaps" and a recent report from the U.S. Department of Defense Science Review Board. Each will be discussed in turn.

In 2011, the United States published a report titled *Unmanned Systems Integrated Roadmap FY2011–2036*.[101] This report considered the technological challenges for testing weapons that are posed by the utilization of sophisticated technologies, including weapon systems with high levels of "net-centricity and automated functionality" that are likely to "introduce unexpected levels of risk."[102] The report concluded, "early-onset T&E and life-cycle T&E will become increasingly critical" in the face of weapons with ever-increasing levels of complication, integration, collaboration and autonomy.[103]

In technologically advanced systems, complexities typically arise with the "unintended and unanticipated interactions between elements that are uncovered only during integration, testing, or once in service."[104] Thus, the report found that:

> Unmanned systems raise new issues of artificial intelligence, communications, autonomy, interoperability, propulsion and power, and manned-unmanned (MUM) teaming that will challenge current T&E capabilities. These problems will get more serious as systems become more interactive and more automated. Failures often occur at the interfaces between system

101. U.S. DEPARTMENT OF DEFENSE, UNMANNED SYSTEMS INTEGRATED ROADMAP FY2011–2036 (2011) [hereinafter UNMANNED SYSTEMS INTEGRATED ROADMAP].

102. *Id.* at 11.

103. *Id.*

104. *Id.* at 10.

> elements, in many cases, between interfaces thought to be separate. The exponential trends in software and network communications increasingly mean that many elements of a system can now affect one another.[105]

The report warned that complex software will require "new approaches for detecting problems earlier in the design phase where cost mitigation is most effective."[106] As a practical matter, "[a]s systems get much of their functionality from software and multisystem interactions, complexity is no longer separate and distinct. Complexity is about the whole ecosystem, and systems engineering has to become more holistic."[107] The report authors suggest the solution to this problem is model-based systems engineering that would allow test data to be used throughout the development, acquisitions, and use of a weapon system.[108]

The U.S. Department of Defense published a second roadmap in 2013 titled *Unmanned Systems Integrated Roadmap FY2013–2038*.[109] This second document discusses testing in much greater detail and provides for the division of responsibility for testing autonomous weapons within the Department of Defense, and articulates standards of testing. Critically, the new roadmap cautions "automation is only as good as the software writer and developer because the control algorithms are created and tested by teams of humans."[110] The report further emphasizes the importance of continuous updates to the system[111] and "well-written and tested software"[112] to ensure correct operations.

Another important policy document identifying challenges with testing autonomous weapons is the U.S. Defense Science Board's 2016 *Summer Study on Autonomy*. The Defense Science Board finds that trust in autonomous systems is "core to the DoD's success in broader adoption of autonomy."[113] Here, trust refers to the satisfaction that an autonomous system will operate in an expected or predictable manner. Establishing trust, the report concludes "is essential, not only for operators and commanders, but also for

105. *Id.* at 11.
106. *Id.*
107. *Id.*
108. *Id.* at 10.
109. *Id.*
110. *Id.* at 67.
111. *Id.*
112. *Id.* at 72.
113. SUMMER STUDY ON AUTONOMY, *supra* note 85, at 1.

designers, testers, policymakers, lawmakers, and the American public."[114] Verification, validation, testing and evaluation procedures establish trust.[115]

Autonomous technologies present special problems for testing systems. The *Unmanned Systems Integrated Roadmap FY2013–2038* finds that "[e]xisting ranges and test facilities have been adequate to test systems with very limited autonomous capabilities."[116] This, of course, suggests that existing ranges and test facilities are inadequate for weapons with advanced autonomous features. This outcome is unsurprising. As the Review Board queries, "How can autonomous systems benefit from T&E when every time they are used they change themselves . . . and how can we verify that systems are learning the right things?"[117] Adaptive systems also have the propensity to exhibit emergent behaviors, that is, they may take unexpected actions. Such adaptability may be militarily beneficial, but predicting such behavior is nearly impossible, and the implications of this uncertainty from a weapon review perspective have already been addressed. As the report readily admits, "it would be difficult to know *a priori* if the collective's adaptive responses would be beneficial or detrimental to a military mission"[118] and "research is required to understand the best ways to test for emergent behavior characteristics."[119]

The *Summer Study on Autonomy* concludes that current conventional testing capabilities are insufficient to ensure the system "will respond appropriately to all of the possible inputs."[120] To resolve this issue, the study recommends using "a combination of modeling and simulation to explore thousands of test cases, statistically measuring system performance against the desired standard, then doing real world testing of the system to ensure that the modeled and real world behavior match for corner cases that span the range of system performance."[121] Much as neural networks are only as good as their training, autonomous systems will only be as good as their modeling and simulation programs.

The Review Board provides several recommendations to address the complexities wrought by autonomous weapons. These recommendations included testing throughout the life cycle of an autonomous weapon system,

114. *Id.*
115. *Id.* at 21.
116. UNMANNED SYSTEMS INTEGRATED ROADMAP, *supra* note 101, at 138.
117. SUMMER STUDY ON AUTONOMY, *supra* note 85, at 13.
118. *Id.* at 84.
119. *Id.* at 32. Within this artide, see *supra* 338–39 for weapon review implications.
120. SUMMER STUDY ON AUTONOMY, *supra* note 85, at 29.
121. *Id.*

as noted above,[122] but also the establishment of new testing paradigms for learning systems,[123] the use of software that can be upgraded without triggering the need for a full system regression testing[124] and the use of "red teams" to attempt to find flaws in the software.[125]

The next Part assesses whether and how the issues raised in the three U.S. documents described above are reflected in any emerging or existing norms regarding the review, control and use of possible future weapons.

IV. POTENTIAL NORMS

At the conclusion of the Forum, the authors sensed that most participants saw no need for a preemptive ban, though all agreed that LAWS, however defined, must comply with existing law. The issue of "control" came up regularly, particularly in the context of compliance with numerous substantive legal rules. For example, how can a legal reviewer be sure a system will comply with the law of armed conflict rule of discrimination if he or she cannot be sure how the system is controlled? Once again, this is not as novel an issue as many pretend: widespread concern over belligerents' ability to control naval mines led to Hague Convention VIII in 1907.[126] Indeed, under the law of armed conflict, the requirement for belligerent control over weapon systems is abundantly clear, whether the weapon system is autonomous or not.

Nonetheless, "control" featured heavily in the discussion of LAWS at CCW and elsewhere. The Forum discussed two concepts for describing how "control" over autonomous technologies might be reflected in the law. One is the concept of "meaningful human control," the other was "authorized power." Whether these concepts would be new, stand-alone norms or simply a way for new and emerging technologies to comply with existing norms is debatable, though it may not matter, so long as the existing legal requirement that weapons be controlled is not denuded by over-reliance on technology. Both concepts are examined in more detail below.

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122. *Id.* at 21.

123. *Id.* at 32.

124. *Id.* at 26.

125. *Id.* at 27.

126. *See* Steven Haines, *1907 Hague Convention VIII Relative to the Laying of Automatic Submarine Contact Mines*, 90 INTERNATIONAL LAW STUDIES 412, 417–20 (2014).

A. Meaningful Human Control

The phrase "meaningful human control" (MHC) is frequently used in the debate over LAWS. The phrase is used by some commentators to define LAWS (LAWS are weapons without MHC, that should, therefore, be banned);[127] others employ it as a way of reflecting social, ethical and legal concerns about how such technologies should be employed (LAWS may be employed so long as they operate under MHC).[128] Some States employ similar phrases in their public pronouncements on LAWS. The United States policy requires commanders and operators to "exercise appropriate levels of human judgment over the use of force,"[129] while the United Kingdom has declared that all weapons will operate under human control.[130] The popularity of the term has prompted the UN Institute for Disarmament Research (UNIDIR) to observe that "for a variety of stakeholders the idea of Meaningful Human Control is intuitively appealing, even if the concept is not precisely defined."[131]

The ICRC has offered its support to the "human control" concept. Nonetheless, the ICRC correctly observes that "it remains unclear whether human control at the stages of the development and the deployment of an autonomous weapon system is sufficient to overcome minimal or no human control at the stage of the weapon system's operation."[132] In their original

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127. *Killer Robots and the Concept of Meaningful Human Control: Memorandum to Convention on Conventional Weapons (CCW) Delegates*, HUMAN RIGHTS WATCH (Apr. 11, 2016, 12:01 AM), https://www.hrw.org/news/2016/04/11/killer-robots-and-concept-meaningful-human-control.

128. *See, e.g.*, CENTER FOR A NEW AMERICAN SECURITY, AUTONOMOUS WEAPONS AND HUMAN CONTROL (2016), https://www.files.ethz.ch/isn/196780/CNAS_Autonomous_Weapons_poster_FINAL%20(1).pdf.

129. Directive 3000.09, *supra* note 19, at 2.

130. *See* United Kingdom of Great Britain and Northern Ireland Statement to the Informal Meeting of Experts on Lethal Autonomous Weapons Systems, General Exchange, *supra* note 23.

131. UNITED NATIONS INSTITUTE FOR DISARMAMENT RESEARCH (UNIDIR), THE WEAPONIZATION OF INCREASINGLY AUTONOMOUS TECHNOLOGIES: CONSIDERING HOW MEANINGFUL HUMAN CONTROL MIGHT MOVE THE DISCUSSION FORWARD 2 (2014), http://www.unidir.org/files/publications/pdfs/considering-how-meaningful-human-control-might-move-the-discussion-forward-en-615.pdf.

132. Statement of the International Committee of the Red Cross, Convention on Certain Conventional Weapons (CCW) Meeting of Experts on Lethal Autonomous Weapons Systems (LAWS) 11–15 April 2016, Geneva (Apr. 11, 2016), https://www.unog.ch/80256EDD006B8954/(httpAssets)/9324B81015529E3DC1257F930057AF12/$file/2016_LAWS+MX_GeneralExchange_Statements_ICRC.pdf.

formulation of MHC, Article 36—the British NGO that coined the term—argued that each individual attack should be initiated only through a positive action by a human operator based on "adequate contextual information on the target area of an attack."[133] Further, Article 36 argued that "adequate contextual information" should include why the target was selected for attack, mission objectives and information regarding the effects of the weapon system.[134] Article 36 has since refined its position, requiring that "those who plan or decide on an attack have sufficient information and control over a weapon to be able to predict how the weapon will operate and what effects it will produce in the context of an individual attack, and thus, to make the required legal judgements."[135] This formulation of MHC appears to recognize that sufficient control can be "baked in" to a weapon system during technological development, combined with the provision of satisfactory human safeguards during an operation to override the technology if there is a problem or an unforeseen circumstance.

Human Rights Watch (HRW) implies that it believes the concept requires human involvement right up to the decision to engage each individual target. Indeed, HRW's 2014 Memorandum for delegates at the Convention on Certain Conventional Weapons states: "Meaningful human control guarantees that human perception and judgment inform the decision about whether to use lethal force in a specific instance."[136] Other entities have put forth similar, though subtly different constructions of the term MHC.[137]

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133. ARTICLE 36, KILLER ROBOTS: UK GOVERNMENT POLICY ON FULLY AUTONOMOUS WEAPONS 4 (2013), http://www.artide36.org/wp-content/uploads/2013/04/Policy_Paper1.pdf.

134. *Id.*

135. ARTICLE 36, KEY AREAS FOR DEBATE ON AUTONOMOUS WEAPONS SYSTEMS: MEMORANDUM FOR DELEGATES AT THE CONVENTION ON CERTAIN CONVENTIONAL WEAPONS (CCW) MEETING OF EXPERTS ON LETHAL AUTONOMOUS WEAPONS SYSTEMS (LAWS) 2 (2014), http://www.artide36.org/wp-content/uploads/2014/05/A36-CCW-May-2014.pdf.

136. *Id.*

137. The International Committee for Robot Arms Control (ICRAC) also advocates for a preemptive ban on autonomous weapons. *See, e.g.*, Frank Sauer, *ICRAC Statement on Technical Issues to the 2014 UN CCW Expert Meeting*, ICRAC: INTERNATIONAL COMMITTEE FOR ROBOT ARMS CONTROL (May 14, 2014) http://icrac.net/2014/05/icrac-statement-on-technical-issues-to-the-un-ccw-expert-meeting/.

> ICRAC holds that the minimum necessary conditions for meaningful human control are
>
> First, a human commander (or operator) must have full contextual and situational awareness of the target area and be able to perceive and react to any change or unanticipated situations that may have arisen since planning the attack.

HRW's approach to MHC perhaps reflects the most exacting expression of this concept. In contrast, some scholars seem to accept that technology, such as facial and voice recognition, might objectively be better than humans at identifying targets and thereby actually *increase* the commander's control over who or what is engaged, and in what circumstances.[138] This is especially the case where the engagement related task devolved to a machine has a clear "right" answer, such as object identification. Where the engagement-related task depends on context or value-based decisions, technology might currently be less effective than a human.[139]

Rapid technological development, however, may mean that machines can make these value decisions in the future. For example, consider that automated dictation technology is now near equal to humans in effectively transcribing the human voice, contrary to the predictions of many researchers based on dubious experiences of the technology when it first emerged.[140] Similarly, in a recent experiment, an AI system beat a group of professional poker players.[141] This development is significant because poker, unlike chess, is a game built on imperfect information. Further, only a year previously, human players soundly defeated an earlier version of the same program, demonstrating the speed at which technology is improving.[142] In another example, several companies have introduced neural network technologies that can diagnose diabetic eye disease with equal or greater precision than doctors

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> Second, there must be active cognitive participation in the attack and sufficient time for deliberation on the nature of the target, its significance in terms of the necessity and appropriateness of attack, and likely incidental and possible accidental effects of the attack.
>
> Third, there must be a means for the rapid suspension or abortion of the attack.

Id.

138. *See, e.g.*, Kenneth Anderson, Daniel Risner & Matthew Waxman, *Adapting the Law of Armed Conflict to Autonomous Weapon Systems*, 90 INTERNATIONAL LAW STUDIES 386 (2014).

139. *See, e.g.*, CENTER FOR A NEW AMERICAN SECURITY, *supra* note 128, at 3, 6.

140. *Now We're Talking: How Voice Technology Is Transforming Computing*, ECONOMIST, Jan. 7, 2017, http://www.economist.com/news/leaders/21713836-casting-magic-spell-it-lets-people-control-world-through-words-alone-how-voice.

141. Jeremy Hsu, *AI Decisively Defeats Human Poker Players*, IEEE SPECTRUM (Jan. 31, 2017, 3:12 PM), http://spectrum.ieee.org/automaton/robotics/artificial-intelligence/ai-learns-from-mistakes-to-defeat-human-poker-players.

142. Will Knight, *Why Poker Is a Big Deal for Artificial Intelligence*, MIT TECHNOLOGY REVIEW, Jan. 23, 2017, https://www.technologyreview.com/s/603385/why-poker-is-a-big-deal-for-artificial-intelligence/.

and can do so in less than one second versus one to five minutes for humans.[143] Other researchers have demonstrated neural network enabled programs that can diagnose cancerous tumors "with far greater frequency than human epidemiologists."[144]

As society becomes more comfortable with the technology, it may become more socially acceptable to have decreasing levels of direct human involvement over an attack.[145] Consider what would happen if technology ever allowed a greater degree of accuracy (through facial mapping or whatever applicable technique), and therefore control over an attack, than an error-prone human? Such technology could provide a military commander with virtual certainty that the right target, and only the right target, would be engaged. Social views of the technology would surely be more favorable if that were ever the case. Further, as a matter of law, when making a choice of means decision under Article 57, the commander could be legally obliged to use the more discriminatory, more accurate AI-based solution.

Thus, despite MHC's initial appeal, it may not turn out to be the normative solution to the issues raised by LAWS. At its extreme, it is likely to be unrealistically restrictive, while at its lowest point, it is little more than a reformulation of existing law, which already requires control over weapon systems. Given the breadth of interpretations of MHC, perhaps another, more precise, approach is called for.

B. Authorized Power

Professor Tony Gillespie has proposed another model for control based on the concept of "authorized power." This model shows that rules, including those from Additional Protocol I and those specifically reviewed under Ar-

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143. James Farrell, *How Stanford Researchers Are Using Deep Learning AI to Fight Blindness*, SILICONANGLE (Jan. 15, 2017, 10:30 PM), http://siliconangle.com/blog/2017/01/15/qa-researchers-stanford-university-explain-deep-learning-technology-fighting-blindness-revolutionizing-healthcare/.

144. Graham Templeton, *AI Beats Doctors at Visual Diagnosis, Observes Many Times More Lung Cancer Signals*, EXTREME TECH (Aug. 18, 2016, 1:00 PM), https://www.extremetech.com/extreme/233746-ai-beats-doctors-at-visual-diagnosis-observes-many-times-more-lung-cancer-signals.

145. *See, e.g.*, Kenneth Anderson & Matthew Waxman, *Law and Ethics for Autonomous Weapon Systems: Why a Ban Won't Work and How the Laws of War Can* (American University Washington College of Law Research Paper No. 2013–11, 2013), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2250126.

ticle 36, can be embedded in the system by the use of suitably derived procurement requirements. This approach ensures, among other properties, that an autonomous system will always be properly subjected to military (and therefore human) command and control.[146] Gillespie's model shows how engineering standards can be set during the procurement phase of a weapon or weapon system that will enable it both to pass an Article 36 review, and to inform the setting of rules of engagement for the system's use by commanders or operators. For this reason, his proposal is both more practical and substantive (although inevitably more technical) than the various MHC models so far proposed. Still, it is not at all inconsistent with the objectives that MHC is intended to meet. Indeed, it should perhaps be seen as a practical means of ensuring the level of control that the law already requires in the context of complex systems.

Gillespie describes complex systems as a hierarchy of decision-making nodes, with each node responsible to the one above it. This command and control structure is also found in a 2002 National Institute of Standards and Technology (NIST) report.[147] The NIST report provides a reference model architecture that "will evolve as technology and standards advance," which "is naturally adaptable to the DoD/Army standards in a combined domain of vehicle systems, combat support, and software engineering."[148] It must be emphasized that a node in a system may be human or machine with its structure based on the traditional "OODA" process: Observe, Orient, Decide, Act. Each node has a defined, predictive capability. Nodes may have a mix of some or all of four possible functional elements, outlined below, which will depend upon the node's role and position in the hierarchy.

1. *Sensory processing*. Creates a "world view" and classifies objects.
2. *World modeling*. Creates and maintains a model of the immediate surroundings; compares this model with information from sensors, predicts future world state, and predicts the consequences of possible system actions on the predicted world state.

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146. Tony Gillespie, Visiting Professor, University College London Department of Electronic and Electrical Engineering, Systems Engineering as a Solution to Legal Problems for Highly-Automated Military Systems, Presentation at the Royal Aeronautical Society Conference: Autonomy Are We There Yet? (June 17, 2016).

147. JAMES S. ALBUS ET AL, U.S. DEPARTMENT OF COMMERCE, NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, 4D/RCS VERSION 2.0: A REFERENCE MODEL ARCHITECTURE FOR UNMANNED VEHICLE SYSTEMS (2002), https://www.nist.gov/publications/4drcs-version-20-reference-model-architecture-unmanned-vehide-systems.

148. *Id.* at 160.

3. *Value judgment*. Weights the consequences of possible actions according to given criteria (including legal criteria). Identifies a range of actions, based upon weighted consequences.
4. *Behavior generator*. Compares the actions identified, then either acts if the plan or range of plans is within the node's authorized power, or refers to a superior when the plans are outside the node's authorized power.

The authorized power of a node is defined as the range of actions the node is allowed to implement without referring to a superior node. An autonomous system comprises nodes that are responsible for each function. Authorized power for each node can and should be pre-determined between the procurement authority, the end user and the weapon-reviewing lawyer. Given this collaborative approach early in the procurement process, what any given node is authorized to do could take account of not only legal concerns, but also social or ethical values, military judgment and any policy or political concerns.

Finally, Gillespie makes the point that, once set, the authorized power can form the basis of testing and evaluation to ensure the node's performance matches expectation.[149] He goes on to say that setting authorized power for nodes in this way "gives the possibility of separating the responsibilities for post-delivery failures between the supplier and user," perhaps answering concerns that increased autonomy on the battlefield risks undermining command or State responsibility for wrongful acts.[150]

V. CONCLUSION

The Forum presented an opportunity to consider how existing law on weapon reviews squares up to examples of likely future technology. In the authors' opinion, it is clear that weapon reviews not only must be applied to any future autonomous weapons, but that the process of doing so is an effective means of keeping unlawful systems from the battlefield without the need for a preemptive ban. The discussion at the Forum showed that many of the criticisms levied at autonomous systems can be rectified if legal reviews are properly conducted during the procurement phase. Where they cannot be rectified, the system would fail its review and its use would not be

149. Gillespie, *supra* note 146.
150. *Id.*

lawful. The Forum also considered how this might be effected in practice. One way is applying the concept of "authorized power" to ensure that autonomous capabilities are properly understood and that they are subjected to the proper level of control already required by law and by military command and control constructs. That being the case, it is all the more regrettable that many States still neglect their obligations under Article 36.

The Forum did not purport to address every issue raised in the LAWS debate at CCW or elsewhere. For example, the Forum focused primarily on the law, not social issues or moral concerns. Furthermore, it focused on one narrow aspect of the regulatory regime: Article 36. Of course, all of IHL applies to the use of autonomy in weapon systems.

Still, the Forum did address key issues. For example, critics of autonomy argue that the lack of human characteristics such as compassion and judgment renders machines incapable of complying with the law of armed conflict. But, this position does not take account of the fact that technology is set to outperform humans in ways and to degrees that are not presently conceivable. Indeed, this article has shown that technology might actually *increase* the commander's control of an engagement, because of better situational awareness and more certain outcomes. This development hardly reflects commanders ceding control over weapon systems or the conduct of operations; rather, the nature of control will change from the physical toward the remote or pre-determined, expressed through sophisticated algorithms discussed and set during a system's procurement, testing and evaluation.

To rule out the use of future technology before its benefits are fully understood might seem reckless, at least in those circumstances. On the other hand, it is abundantly clear that warfare must remain closely controlled and directed by human commanders. The Second International Weapon Review Forum demonstrated how existing law, properly applied to emerging technologies, contributes to meeting that requirement.