

**THE ECONOMIC CALCULUS OF FIELDING  
AUTONOMOUS FIGHTING VEHICLES COMPLIANT  
WITH THE LAWS OF ARMED CONFLICT**

Evan Wallach\* and Erik Thomas\*\*

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**ABSTRACT**

*The U.S. military and others worldwide have undergone a rapid evolution in the numbers, sophistication and lethality of the robotic weaponry that they deploy to the battlefield. The rate of transformation in the field of robotics and weapons technology raises numerous questions about what legal considerations should be made as we approach the step beyond remotely controlled drone weaponry to fully autonomous fighting vehicles as human operated weapons evolve into self-directed warriors.*

*This Article examines the interplay between the obligation to produce legally compliant weapons and their economic costs, and assesses how these costs may influence AFV design. Based upon our analysis of this relationship we provide recommendations to policymakers, including technical design improvements, cost/compliance policy considerations, modifications to increase command battlefield legal compliance awareness, and increased policymaker awareness of AFVs' legal compliance advantages.*

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\* Circuit Judge, U.S. Court of Appeals for the Federal Circuit; Adjunct Professor of Law, The George Washington University Law School; Honorary Fellow, Hughes Hall College, University of Cambridge; J.D., University of California, Berkeley, 1976; L.L.B., Public International Law, University of Cambridge, 1981; Judge Advocate Officer Advanced Course, The Judge Advocate General's Legal Center and School, 1992. This paper represents entirely the work of the author and not necessarily the position of any institution with which he is affiliated.

\*\* J.D., George Washington University Law School, 2015; B.A. (Philosophy), Reed College, 2012.

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## INTRODUCTION

In 2001, the U.S. Military had only 162 unmanned aerial vehicles, commonly referred to as drones.<sup>1</sup> By 2010, that number exceeded 7,000, accounting for 41% of aircrafts in the U.S. Air Force.<sup>2</sup> As their numbers have increased, these systems have become increasingly automated.<sup>3</sup> Newly deployed weapon systems have taken the first steps towards target selection without input from human operators.<sup>4</sup> The revolution in robotics and weapons technology raises numerous questions about the legality of deploying Autonomous Fighting Vehicles (AFVs) onto the battlefield.

As human-operated weapons evolve into self-directed warriors, the applicable legal framework expands beyond the traditional determination of weapons' compliance with the law,<sup>5</sup> imposing additional positive and negative requirements.<sup>6</sup>

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<sup>1</sup> JEREMIAH GERTLER, CONG. RESEARCH SERV., R42136, U.S. UNMANNED AERIAL SYSTEMS 2 (2012).

<sup>2</sup> As of 2010, the United States had 7,494 Unmanned Aerial Vehicles as compared to 10,767 manned aircraft. *Id.* at 9.

<sup>3</sup> In 2009 the Global Hawk automated spy plane used by the U.S. Air Force was capable of taking off and landing by itself, and carrying out an observation mission using GPS data without any pilot remotely guiding it. Technology has significantly advanced since that time. *RQ-4 Global Hawk Maritime Demonstration System*, NORTHROPGRUMMAN.COM (Apr. 14, 2007), <http://www.northropgrumman.com/Capabilities/RQ4Block10GlobalHawk/Documents/GHMD-New-Brochure.pdf> [<https://perma.cc/K6RT-YVVA>].

<sup>4</sup> *South Korea Deploys Robots To Detect and Kill Intruders*, TORONTO STAR (July 14, 2010), [http://www.thestar.com/news/world/2010/07/14/south\\_korea\\_deploys\\_robots\\_to\\_detect\\_and\\_kill\\_intruders.html](http://www.thestar.com/news/world/2010/07/14/south_korea_deploys_robots_to_detect_and_kill_intruders.html) [<https://perma.cc/MF74-PBDT>].

<sup>5</sup> See W. Hays Parks, *Means and Methods of Warfare*, 38 GEO. WASH. INT'L L. REV. 511, 516 (2006) (discussing U.S. weapons review policy).

<sup>6</sup> Positive requirements, for example, mandate effectiveness, accuracy, and composition of weapons and ammunition. 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, 19 I.L.M. 1523. Negative requirements, on the other hand, ban classes and uses of weapons. See, e.g., Convention on the Prohibition of the Development, Stockpiling, and Use of Chemical Weapons and on Their Destruction,

The guiding principles for use and deployment (for example proportionality, military necessity, and chivalry) remain the same.

This paper examines the interplay between the obligation to produce legally compliant weapons and the economic costs of those weapons, and assesses how these costs may influence AFV design. We begin by defining an autonomous weapon system. We then examine obligations imposed by the Law of Armed Conflict and Customary International Humanitarian Law on AFVs. In particular, we evaluate how the Law of Armed Conflict influences AFV design, construction, and inventory maintenance. We conclude with recommendations for executive and legislative policymakers, including technical design improvements, cost and compliance policy considerations, modifications to increase command battlefield awareness of legal compliance, and increased policymaker awareness of AFVs' legal compliance advantages.

## I. Automation and True Autonomy in Weapon Systems

The continuum from human control of the use of lethal force to complete autonomy begins in automated weapon systems. An automated weapon system is designed to automatically engage a target when certain pre-determined parameters are detected.<sup>7</sup> Automated weapon systems have a long history. The pit trap and its technological successors, the land and sea mine, are examples of early automated weapons systems.<sup>8</sup> They are "victim activated." The target actuates the weapon, but there is little or no ability to distinguish among targets.

Newer weapon systems are advancing towards a dynamic in which the weapon systems have a greater capacity to both identify targets and choose not to activate against inappropriate ones. For example, new anti-vehicle mines have the capacity to distinguish between "friendly" vehicles and

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Jan. 13, 1993, 32 I.L.M. 800; cf. Evan Wallach, *Pray Fire First Gentlemen of France: Has 21<sup>st</sup> Century Chivalry Been Subsumed by Humanitarian Law?*, 3 HARV. NAT'L SEC. J. 431 (2012).

<sup>7</sup> Alan Backstrom & Ian Henderson, *New Capabilities in Warfare: An Overview of Contemporary Technological Developments and the Associated Legal and Engineering Issues in Article 36 Weapons Reviews*, 94 INT'L REV. OF THE RED CROSS, Summer 2012, at 488, <https://www.icrc.org/eng/assets/files/review/2012/irrc-886-backstrom-henderson.pdf> [<https://perma.cc/Y4ED-B9TG>].

<sup>8</sup> Kenneth Anderson, Daniel Reisner & Matthew C. Waxman, *Adapting the Law of Armed Conflict to Autonomous Weapon Systems*, 90 INT'L L. STUD. 386, 388 (2014), <http://ssrn.com/abstract=2477095> [<https://perma.cc/3Y3P-PCLD>].

“enemy” vehicles based on whether they meet certain sensor signatures.<sup>9</sup> As technology has evolved, these systems have gained greater range and ability to choose their own targets, moving them into the realm of autonomous weapons.<sup>10</sup>

Lawful autonomous weapon systems are defined in our analysis as weapons that have the capacity, without human intervention, to identify, engage, and attack legitimate targets without violating any law governing armed conflict. They may or may not have the capacity to learn and adapt their battlefield behavior without further human intervention or programming.<sup>11</sup> Some deployed weapon systems are capable of defensive autonomous reactive targeting of perceived non-human targets due to these systems’ necessarily short reaction

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<sup>9</sup> Backstrom & Henderson, *supra* note 7, at 490. In addition, some systems self-destruct after a limited period of deployment for tactical reasons and as a safeguard against unintentional use against non-combatants. For example, certain anti-vehicle mines developed by the United States self-destruct after between 12 and 72 hours from deployment. *See* U.S. GOV’T ACCOUNTABILITY OFFICE, GAO-02-1003, MILITARY OPERATIONS: INFORMATION ON THE U.S. USE OF LAND MINES IN THE PERSIAN GULF WAR 39 (2002) (noting that of the nearly 18 million land mines in the United States stockpile in 2002, 15 million were equipped to self-destruct).

<sup>10</sup> *See, e.g., Harop Loitering Munitions UCAV System, Israel*, AIRFORCE-TECHNOLOGY.COM, <http://www.airforce-technology.com/projects/haroploiteringmuniti> [<https://perma.cc/VY4V-9YHP>].

<sup>11</sup> While predicting the exact nature and capacity of future autonomous systems is outside the scope of this article, current computer research strongly suggests that future systems will have the capacity to learn. The Watson Computer provides one current example of a machine learning process. *See What Is Watson*, IBM, <http://www.ibm.com/smarterplanet/us/en/ibmwatson/what-is-watson.html> [<https://perma.cc/KN3F-H5NZ>]. Computer learning could present substantial and problematic issues, if, for example, a weapon had the capacity to develop a preference for self-preservation over mission completion and legal compliance.

times.<sup>12</sup> Indeed, potentially offensive autonomous targeting decisions occur in some currently deployed weapons systems.<sup>13</sup>

## II. International Law Concerning the Legality of Deploying Autonomous Weapon Systems

International law mandates that contracting nations determine whether a developing weapon system is compliant with the unvarying requirements of the laws of war.<sup>14</sup> An autonomous weapon system must observe the core principles of the Law of Armed Conflict: distinction, military necessity,

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<sup>12</sup> Examples of defensive weapon systems selecting targets and firing without human interference include the AEGIS anti-missile defense system introduced into U.S. warships in the 1980s. The AEGIS system had a mode in which it was able to fire without any human selection of targets. The AEGIS Cruiser U.S.S. Vincennes's destruction of Iran Air Flight 655, which resulted in 290 deaths, demonstrates the potential flaws of such systems. U.S. DEPT OF DEF., FORMAL INVESTIGATION INTO THE CIRCUMSTANCES SURROUNDING THE DOWNING OF IRAN AIR FLIGHT 655 ON 3 JULY 1988, [http://www.dod.gov/pubs/foi/Reading\\_Room/International\\_Security\\_Affairs/172.pdf](http://www.dod.gov/pubs/foi/Reading_Room/International_Security_Affairs/172.pdf) [<https://perma.cc/JKZ7-M3FY>]. Similarly, the Counter Rocket, Artillery, and Mortar (CRAM) system deployed in Iraq is designed to identify and automatically shoot down incoming mortar shells without any human command to fire. PETER W. SINGER, WIRED FOR WAR 124 (2009).

<sup>13</sup> The Israeli Harpy and Harop Loitering Attack Systems are current examples of offensive autonomous targeting. The Harpy consists of an unmanned combat aerial vehicle which deploys over a battle space for an extended period of time. The system includes an anti-radar homing system, which allows the Harpy to attack any radar source that it detects within a certain area. As a result, while the human commander will designate the area in which the Harpy should patrol and target, the actual decision to attack any one target is completely automated. *Harop Loitering Munitions UCAV System, Israel*, AIRFORCE-TECHNOLOGY.COM, <http://www.airforce-technology.com/projects/haroploiteringmunitions/> [<https://perma.cc/3TZQ-W2GW>]; see also *Harpy Air Defense Suppression System*, DEFENSE-UPDATE.COM (Mar. 4, 2006), <http://defense-update.com/directory/harpy.htm> [<https://perma.cc/JYB9-EHNB>].

<sup>14</sup> Article 36 of the 1977 Additional Protocol I 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." Protocol Additional to the Geneva Conventions of 12 August 1949, and Relating to the Protection of Victims of International Armed Conflicts (Protocol I) art. 36, June 8, 1977, 1125 U.N.T.S. 3 [hereinafter Protocol I]. While the United States is not a party to Protocol I, in practice it observes Article 36 and effectively treats it as a rule of customary international law. See Kenneth Anderson & Matthew C. Waxman, *Law and Ethics for Autonomous Weapon Systems: Why a Ban Won't Work and How the Laws of War Can* (Stan. U., The Hoover Inst., Jean Perkins Task Force on Nat'l Security and Law Essay Series, 2013), at 10, <http://ssrn.com/abstract=2250126> [<https://perma.cc/72QV-PG2S>].

proportionality, chivalry,<sup>15</sup> and avoiding unnecessary suffering.<sup>16</sup> Given AFVs' capacity to operate independently and lethally, their deployment and design also implicate laws concerning command responsibility. This paper will primarily focus on distinction and command responsibility.<sup>17</sup>

### A. *The Principle of Discrimination and Its Application to AFVs*

A prime deployment issue is whether an autonomous weapons system is capable of adequate target discrimination. Combatants are required to observe the principle of "distinction" (i.e. discrimination),<sup>18</sup> which prohibits 1) the use of

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<sup>15</sup> As has been argued previously, an AFV may satisfy the necessary principle of chivalry, which includes both positive requirements, such as mercy, courage, trustworthiness, and loyalty, and negative prohibitions, such as those banning treachery, perfidy, and breach of parole. See Wallach, *supra* note 6.

<sup>16</sup> See, e.g., U.S. DEP'T OF ARMY, *The Law of Land Warfare* ¶ 3, in FIELD MANUAL 27-10, (July 1956); UK MINISTRY OF DEFENCE, JOINT DOCTRINE NOTE 2/11: THE UK APPROACH TO UNMANNED AIRCRAFT SYSTEMS, 2011, ¶ 507 (arguing that an autonomous weapon system could be allowed to make the decision to use lethal force "provided it could be shown that the controlling system appropriately assessed the LOAC principles (military necessity; humanity; distinction and proportionality) and that ROE (Rules of Engagement) were satisfied, this would be entirely legal."); see also GARY D. SOLIS, *THE LAW OF ARMED CONFLICT: INTERNATIONAL HUMANITARIAN LAW IN WAR* 285 (2010) (stating that the principles of distinction, military necessity, avoiding unnecessary suffering, and proportionality are the core principles of the law of armed conflict); Evan Wallach, *Interactive Casebook of the Law of War: Chapter 2, General Principles*, INT'L L. OF WAR ASS'N (Dec. 8, 2010), <http://lawofwar.org/principles.htm> (stating that the principles of avoiding unnecessary suffering, military necessity, and proportionality are the core principles of the law of armed conflict).

<sup>17</sup> We will focus upon the issues relating to target discrimination and command responsibility, rather than the remaining four core principles, because target discrimination and command responsibility pose challenges unique to AFV development which are not present in weapon systems in which human control over target selection is maintained.

<sup>18</sup> The principle of distinction is specifically enshrined in Article 48 of Additional Protocol I of the Geneva Conventions which states, "[T]he Parties to the conflict shall at all times distinguish between the civilian population and combatants." Protocol I, *supra* note 14, art. 48. The International Committee of the Red Cross (ICRC) further defines the principle of discrimination, by stating that "[t]he parties to the conflict must at all time distinguish between civilians and combatants. Attacks may only be directed against combatants. Attacks must not be directed against civilians." 1 JEAN-MARIE HENCKAERTS & LOUISE DOSWALD-BECK, *CUSTOMARY INTERNATIONAL HUMANITARIAN LAW*, at 11 (2005), available at <https://www.icrc.org/eng/assets/files/other/customary-international-humanitarian-law-i-icrc-eng.pdf> [<https://perma.cc/KT7B-V85B>]. While Additional Protocol I has not been ratified by the United States, the principle of distinction is well established in U.S. law. Article 22 of the 1863 Lieber Code states, "[A]s civilization has advanced during the last

weapon systems that indiscriminately strike both lawful and unlawful targets, and 2) the indiscriminant use of a weapon regardless of its accuracy.<sup>19</sup> A conventional weapon system need only be designed in a way that places the burden on the operator to employ it in a discriminatory manner. An autonomous weapon system, on the other hand, must comply with both facets since it selects and strikes a target.

Already there is a spectrum of responsibility between full machine and full human responsibility for AFV target selection. As autonomous weapons systems have become more sophisticated, the extent to which a human or machine exercises the principle of distinction has begun to shift. For example, in traditional automated weapon systems such as land mines, the principle of discrimination was exercised by the military commander through the placement of mines in either marked locations or locations where they were unlikely to be triggered by civilians.<sup>20</sup> In contrast, those deploying a system such as the Harpy, which patrols a broad geographic area, cannot rely on the absence of civilians from its targeting area as a means of discrimination. To meet the distinction requirement, a new autonomous weapon system must have an effective means of distinguishing civilian from military targets. Minimum technical requirements for distinction in any autonomous system can be met only at a significant price, potentially requiring sophisticated targeting sensors and the software and computing power to fully and immediately process the sensor data.<sup>21</sup>

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centuries, so has likewise steadily advanced, especially in war on land, the distinction between the private individual belonging to a hostile country and the hostile country itself, with its men in arms.” FRANCIS LIEBER, U.S. WAR DEP’T, General Orders No. 100, INSTRUCTIONS FOR THE GOVERNMENT OF ARMIES OF THE UNITED STATES IN THE FIELD, art. 22 (1863), *available at* [http://avalon.law.yale.edu/19th\\_century/lieber.asp](http://avalon.law.yale.edu/19th_century/lieber.asp) [<https://perma.cc/SW4Q-MBVN>]. The United States has also stated that it recognizes that Article 48 of Protocol I is regarded as a codification of the customary practice of nations and is therefore binding on all nations. U.S. DEP’T OF DEF., CONDUCT OF THE PERSIAN GULF WAR: FINAL REPORT TO CONGRESS, APPENDIX O, THE ROLE OF THE LAW OF WAR 614 (1992), *available at* <http://babel.hathitrust.org/cgi/pt?id=uiug.30112004365182;view=1up;seq=1> [<https://perma.cc/5GSA-XA7Z>].

<sup>19</sup> See Michael N. Schmitt, *The Principle of Discrimination in 21st Century Warfare*, 2 YALE HUM. RTS. & DEV. L.J. 143, 147-148 (1999).

<sup>20</sup> Examples of this practice include the placement of mines on active battlefronts or areas closed to civilians such as the Demilitarized Zone between North and South Korea.

<sup>21</sup> Even in the current non-autonomous generation of aircraft, sensors make up an extensive portion of a vehicle’s costs. Even at the low end of the cost spectrum, the costs of the lightweight electro-optical/infrared cameras on vehicles like the Desert Hawk and Dragon Eye UAV greatly exceed the design costs of those vehicles. At the high end, the RQ-4B Global Hawk’s sensor suite accounts for 54% of the aircraft’s overall cost.

B. *Command Responsibility and Its Application to AFVs*

Commanders bear responsibility for the actions of their troops even when their troops act outside the commander's orders.<sup>22</sup> In 1947, in *In re Yamashita*, the United States Supreme Court cited the Annex to the Hague Convention of 1907 for the principle that an armed force must be "commanded by a person responsible for his subordinates" to be accorded the rights of lawful belligerents.<sup>23</sup> As part of these responsibilities, a military commander has several important duties, failure of which constitutes a war crime.<sup>24</sup> Three aspects of a commander's responsibility are particularly implicated by autonomous weapon systems: the duty to train troops in the laws of war, the duty to control troops, and the duty to monitor and punish.

Commanders are responsible for ensuring that their troops are trained in the Law of Armed Conflict. Under Geneva Convention I of 1949 Article 47, contracting nations have an obligation to include lessons on the Convention in their military instruction.<sup>25</sup> In the case of AFVs, the obligation to properly train is effectively replaced by an obligation to

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JEREMIAH GERTLER, CONG. RESEARCH SERV., R42136, U.S. UNMANNED AERIAL SYSTEMS 15 (2012).

<sup>22</sup> See Evan Wallach & I. Maxine Marcus, *Command Responsibility*, in 3 INTERNATIONAL CRIMINAL LAW 459, 459-60 (M. Cherif Bassiouni ed., 3d ed. 2008); see also SOLIS, *supra* note 16, at 382 (citing an edict by Charles VII of Orleans in 1439 stating that "each Captain and Lieutenant [will] be held responsible for the abuses and offenses committed by members of his company [and if] the offender thus escapes and evades punishment, the [officer] will be deemed responsible for the offense as if he had committed it himself . . ."); Headquarters Dist. of the Border, U.S. Dep't of Army, Gen. Order No. 10, § 5 (Aug. 18, 1863) ("Commanders of companies and detachments serving in Missouri will not allow persons not in the military service of the United States to accompany them on duty except when employed as guides, and will be held responsible for the good conduct of such men employed as guides and for their obedience to orders."); Convention (IV) Respecting the Laws and Customs of War on Land: Regulations Concerning the Laws and Customs of War on Land, Oct. 18, 1907, Annex, art. I, 36 Stat. 2277, 2295 (requiring that an army be commanded by "a person responsible for his subordinates").

<sup>23</sup> *In re Yamashita*, 327 U.S. 1, 15 (1946).

<sup>24</sup> See SOLIS, *supra* note 16, at 391-96.

<sup>25</sup> "The High Contracting Parties undertake, in time of peace as in time of war, to disseminate the text of the present Convention as widely as possible in their respective countries, and, in particular, to include the study thereof in their programmes of military and, if possible, civil instruction, so that the principles thereof may become known to the entire population, in particular to the armed fighting forces, the medical personnel and the chaplains." Geneva Convention (I) for the Amelioration of the Condition of the Wounded and Sick in Armed Forces in the Field art. 47, August 12, 1949, 6 U.S.T. 3114, 75 U.N.T.S. 31.



properly program. AFVs differ significantly from regular troops, however, in that a greater investment of resources in programming and processing necessarily increases the AFVs ability to implement the Law of Armed Conflict. Commanders and their lawyers, of course, will require compliance training more than ever.<sup>26</sup>

A commander also has a duty to control subordinates; otherwise their crimes may be imputed.<sup>27</sup> With human combatants, the obligation is generally fulfilled through Rules of Engagement.<sup>28</sup> To satisfy this obligation, commanders need a means to program (re-train) and disable a malfunctioning AFV. These additional requirements further increase the cost of a weapon system. To reprogram an AFV, a commander must, at least in the foreseeable future, possess an ability to require conduct specific to the area of operations. For the latter, the AFV designer will not only need to incorporate something like a “kill-switch,” but also invest in security measures to prevent activation of the switch by the enemy. An alternative approach might require machines to periodically check in or return to base. That, however, might require the purchase of a larger number of AFVs than otherwise necessary.<sup>29</sup>

Finally, a commander is responsible for investigating Law of Armed Conflict violations about which she is or should have been aware.<sup>30</sup> Under the “should have known standard” a commander does not need to have specific knowledge that a crime has been committed and can be held liable for ignoring

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<sup>26</sup> See Evan Wallach & Keith Zemsky, *I'm Sorry Dave, I'm Afraid I Can't Do That; Best Practices for Commanders of Fully Autonomous Fighting Vehicles* (on file with author).

<sup>27</sup> *In re Yamashita*, 327 U.S. at 15.

<sup>28</sup> See U.S. DEP'T OF ARMY, *Legal Support to the Operational Army 7-1*, in FIELD MANUAL 1-04, (March 18, 2013); Evan Wallach, *Interactive Casebook of the Law of War: Chapter 4.3, Rules of Engagement*, INT'L L. OF WAR ASS'N (Dec. 8, 2010), <http://lawofwar.org/Decision%20Making.htm> [<https://perma.cc/M85R-MUQK>].

<sup>29</sup> If an AFV is required to return to base more frequently, a larger number of AFVs will be needed to maintain coverage within a combat zone. Consider, for example, an AFV being used to blockade a port. If the AFV is capable of remaining on station for years and patrolling indefinitely, but it must return back to base periodically for check-ins, another AFV will be required to replace the first one while it is in transit to and from its home port. This challenge is similarly demonstrated through the phenomenon of “blinking” in which video coverage of a target by drone is lost due to necessary movement without a replacement drone available. Quinta Jurecic, *What the Intercept Found in “The Drone Papers” – And What I Found in Them*, LAWFARE (Oct. 16, 2015, 5:20 PM), <https://www.lawfareblog.com/what-intercept-found-drone-papers—and-what-i-found-them> [<https://perma.cc/8VL4-PY3Q>].

<sup>30</sup> SOLIS, *supra* note 16, at 392.

violations of the Law of Armed Conflict by his troops.<sup>31</sup> Therefore, any commander who deploys AFVs must have some method of monitoring their actions and behavior to ensure that they are not violating the Law of Armed Conflict, and a means of verification should any general information arise suggesting misconduct. Accordingly, AFV designers must include a recording mechanism that is available for inspection. Current United Kingdom military doctrine, for example, recognizes a duty to include recording and information transmission systems in AFVs that operate autonomously for an extended period of time, so that commanders can monitor the AFVs' activity.<sup>32</sup>

The governing principles described above are immutable. The conflict we discuss here is how these principles fare in the face of a range of economic realities governing states' conduct. Indeed, even the richest state must be able to determine whether, in light of its always eventually limited economic resources, it must maintain certain numbers of weapons with certain capacities, especially given the eventual obsolescence of unused inventories.

### III. Effect of Economic Costs on the Implementation of Compliance Systems in AFVs

The economic capacity of the combatant state affects the kinds of weapons systems it may deploy in a conflict. The combatant state must: "take all *feasible* precautions in the choice of means and methods of attack with a view of avoiding, and in any event to minimizing, incidental loss of civilian life, injury to civilians and damage to civilian objects."<sup>33</sup> The word

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<sup>31</sup> "The 'had reason to know' standard does not require that actual knowledge, either explicit or circumstantial, be established. Nor does it require that the Chamber be satisfied that the accused actually knew that crimes had been committed or were about to be committed. It merely requires that the Chamber be satisfied that the accused had 'some general information in his possession, which would put him on notice of possible unlawful acts by his subordinates.'" Prosecutor v. Bagilishema, Case No. ICTR-95-1A-A, Judgment, ¶ 28 (July 3, 2002).

<sup>32</sup> JOINT DOCTRINE NOTE 2/11: THE UK APPROACH TO UNMANNED AIRCRAFT SYSTEMS *supra* note 16, at ¶ 510. ("For long-endurance missions engaged in complex scenarios, the authorized entity that holds legal responsibility will be required to exercise some level of supervision throughout. If so, this implies that any fielded system employing weapons will have to maintain a 2-way data link between the aircraft and its controlling authority. A complex weapon system is also likely to require an authorisation and decisions log, to provide an audit trail for any subsequent legal enquiry.")

<sup>33</sup> Protocol I, *supra* note 14, art. 57 (emphasis added). While the United States has not ratified Protocol I, it has since indicated which Articles contain principles it supports and will seek to follow, and has stated that

“feasible” is important; it applies different standards of conduct to combatants, commensurate with their technical and economic capacities.<sup>34</sup>

The evolution of technology and practice in aerial bombardment demonstrates how the definition of “feasible precautions” can vary. As technology has advanced, the availability of feasible measures for reducing civilian casualties has increased. In 1972 during the Linebacker II B-52 bombing of targets near Hanoi and Haiphong in Vietnam, “Strategic Air Command B-52 radar navigators were briefed to return from their missions without dropping their bombs unless they were one hundred percent certain of their aiming point. All B-52 target maps contained the locations of schools, hospitals, and prisoner of war camps, and briefers brought such sites to the attention of a crew if its bomb run was in the proximity of any such object.”<sup>35</sup> Those were the maximum feasible measures

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it supports the principles contained within Article 57. In 1987 the Deputy Legal Advisor for the United States Department of State, Michael Matheson presented a prepared statement on which aspects of Protocol I the United States considered customary International Law to the American Red Cross-Washington College of Law Conference on International Humanitarian Law. In his presentation Mr. Matheson indicated that it was the position of the United States that it supported the principle that “all practicable precautions, taking into account military and humanitarian considerations, be taken in the conduct of military operations to minimize incidental death, injury, and damage to civilians and civilian objects, and that effective advance warning be given of attacks which may effect the civilian population, unless circumstances do not permit . . . . These various principles are reflected in articles 57-60.” This statement by the United States and the ratification by 174 nations of Protocol I indicate that Article 57 is customary International Law which would be binding on all combatants. Martin P. Dupuis et al., *The Sixth Annual American Red Cross-Washington College of Law Conference on International Humanitarian Law: A Workshop on Customary International Law and the 1977 Protocols Additional to the 1949 Geneva Conventions; Session One: The United States Position on the Relation of Customary International Law to the 1977 Protocols Additional to the 1949 Geneva Conventions*, 2 AM. U. INT’L L. REV. 415, 426-27 (1987).

<sup>34</sup> The U.S. military may take an opposing viewpoint to this position. According to Kenneth Anderson and Matthew Waxman, under the current U.S. view with regards to discrimination, the same absolute rules bind every combatant, not a relative standard related to capabilities. Kenneth Anderson & Matthew C. Waxman, *Law and Ethics for Robot Soldiers*, Columbia Pub. L. Res. Paper No. 12-313, at 8-9 (2012), <http://ssrn.com/abstract=2046375> [<https://perma.cc/9VSP-BZZZ>]. Taken to its logical extreme, that position would require states with limited resources to use suicide bombers in place of smart weapons, when targeting areas where noncombatants might be harmed.

<sup>35</sup> W. Hays Parks, *Air War and the Law of War*, 32 A.F. L. REV. 1, 154 (1990).

available to heavy bombers in 1972.<sup>36</sup> The evolution of precision or smart bombs, which enable a combatant to more closely target a specific military objective, and reduce the chance of accidentally hitting nearby civilians, has changed that equation.<sup>37</sup>

The shift towards precision bombing is particularly noticeable in the case of the U.S. military. In the first Gulf War in 1991, 7% of the bombs used were precision-guided weapons.<sup>38</sup> In the second invasion of Iraq in 2003, 70% of the bombs and missiles were precision-guided.<sup>39</sup> However, precision bombing technology has spread unevenly and wealthy states maintain a substantial technical lead over less developed nations. One could envision conflicts where one combatant is required to take more significant efforts to avoid civilian casualties than the other because of its superior capacity to do so.

The Syrian Civil War provides a current example of this mismatch. In the September 21, 2014 strikes by U.S. forces against Islamic State forces, 96% of the weapons used were precision-guided.<sup>40</sup> The Syrian Air Force lacks precision-guided weapons, instead using a mix of conventional dumb bombs and “barrel bombs” (oil barrels filled with explosives dropped off the side of helicopters).<sup>41</sup> Given this technical capacity, it would be beyond the Syrian Air Force’s feasibility requirements to use precision weapons in its attacks.<sup>42</sup> Article 57, however, still

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<sup>36</sup> Television-guided bombs did exist in 1972 but their use was restricted to highly trained teams of light bombers. Examples include the AGM-62 Walleye II, which was also deployed during the Linebacker bombing campaign. *AGM-62 Walleye II*, GLOBALSECURITY.ORG (July 7, 2011), <http://www.globalsecurity.org/military/systems/munitions/agm-62.htm> [<https://perma.cc/Y7N9-NRG4>].

<sup>37</sup> An examination of some of the new and evolving capacities of precision guided munitions can be found in J.R. Wilson, *The Future of Precision Guided Munitions*, MIL. & AEROSPACE ELECTRONICS (Dec. 1, 2009), <http://www.militaryaerospace.com/articles/print/volume-20/issue-12/features/special-report/the-future-of-precision-guided-munitions.html> [<https://perma.cc/34VV-8FMK>].

<sup>38</sup> Sean J.A. Edwards, *Swarming and the Future of Warfare* 280 (2005) (unpublished doctoral thesis, Pardee Rand Graduate School), *available at* [http://www.rand.org/content/dam/rand/pubs/rgs\\_dissertations/2005/RAN\\_D\\_RGSD189.pdf](http://www.rand.org/content/dam/rand/pubs/rgs_dissertations/2005/RAN_D_RGSD189.pdf) [<https://perma.cc/X4XN-9NS3>].

<sup>39</sup> *Id.*

<sup>40</sup> Mark Thompson, *These are the Weapons the U.S. is Using to Attack ISIS*, TIME, Sept. 23, 2014, <http://time.com/3422702/isil-isis-syria-obama> [<https://perma.cc/8FG5-ZAV4>].

<sup>41</sup> Richard M. Lloyd, *Syria’s Barrel Bomb Technology Relative to Aleppo Syria Attacks – The Good, The Bad And The Ugly*, BROWN MOSES BLOG (Dec. 22, 2013), <http://brown-moses.blogspot.co.uk/2013/12/syrias-barrel-bomb-technology-relative.html> [<https://perma.cc/KWU2-5G9T>].

<sup>42</sup> The principles governing the use of force are, of course, consistent; their application varies with capacity.

requires the Syrian Air Force to take measures within its capacity to protect noncombatants, including not targeting civilian areas, and to apply the principles of military necessity and proportionality—requirements the Syrian Air Force appears to have consistently violated.<sup>43</sup>

A. *An Approach for Evaluating the Feasibility of Measures to Avoid Civilian Casualties*

There is no minimum technical specification that an AFV must possess to be fully compliant with the Law of Armed Conflict.<sup>44</sup> Instead, under Article 57 one must examine whether it is feasible for a combatant to improve the mechanisms and procedures for avoiding civilian casualties. In examining that requirement under Article 57(a), one cannot limit analysis to mere technical feasibility. While determining whether to use a weapon system or add a particular safety feature, one should consider its effectiveness along three different axes: 1) the military effectiveness of the weapon, 2) the cost of the weapon, and 3) the danger of civilian casualties from use of the weapon.<sup>45</sup>

The easiest case to evaluate is a commander faced with the choice between two weapon systems, system A and system B, of equal cost and military effectiveness. If the use of system A would cause more civilian casualties than system B, system A would clearly fail the feasibility test. In this scenario, it would be equally feasible to field a weapon that posed less risk

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<sup>43</sup> These measures include, *inter alia*, not targeting non-military areas, dropping leaflets to warn the civilian population to depart areas of anticipated conflict, developing highly detailed targeting maps, and requiring bomber crews to take measures to increase accuracy. See C.J. Chivers, *Syria Unleashes Cluster Bombs on Town, Punishing Civilians*, N.Y. TIMES, Dec. 20, 2012, <http://www.nytimes.com/2012/12/21/world/middleeast/syria-uses-cluster-bombs-to-attack-as-many-civilians-as-possible.html> [<https://perma.cc/39AG-E44H>]; Parks, *supra* note 35, at 165-166.

<sup>44</sup> As is shown regarding aerial bombardment, *supra* Part IV, the technical specifications of an AFV vary depending on the technical and economic capacity of the deploying country, and can vary over time in the same country as technology advances.

<sup>45</sup> In determining the feasibility of deploying a particular weapon system or weapon system safety feature, we have chosen to use cost as an axis of evaluation over technical capacity due to the way in which cost is able to account for additional variables affecting a combatant's ability to acquire or produce a weapon system. These factors include issues such as arms embargoes, lack of access to necessary raw materials, and price gouging by suppliers. See, e.g., Eric B. Golson, *Did Swedish ball bearings keep the Second World War going? Re-evaluating neutral Sweden's role*, 60 SCANDINAVIAN ECON. HIST. REV. 165 (2012) (discussing the essential role that Swedish ball bearings played in German arms manufacturing and the damage to production caused by blockades of that supply).

to the civilian population.<sup>46</sup> Furthermore, beyond failing the feasibility test outlined in Article 57, the choice to deploy system A would also be against the spirit of two other closely related principles of the Law of Armed Conflict: proportionality and the ban on the employment of weapons that cause superfluous injury or unnecessary suffering.<sup>47</sup> While neither principle is directly relevant, both demonstrate a clear and unmistakable intent to ban weapons that increase human suffering without providing an additional military advantage.

Efforts to reduce civilian casualties may hinder a state's ability to effectively deploy the weapon system, either by reducing the weapons system's military effectiveness or by prohibitively increasing its cost. In the remainder of this paper, we will focus on how combatants should evaluate these tradeoffs, focusing on the tradeoff between the cost of an autonomous weapon system and the potential civilian casualties from its deployment.

*B. Choosing Proper Frames of Evaluation and Their Effects on Cost Feasibility Estimates*

The economic feasibility of adding a feature to a weapon system to reduce civilian casualties can vary greatly depending on the reference frame. The two primary frames available are the "weapon system level" and the "overall budget level."<sup>48</sup> The former model evaluates, at the level of each weapon system, whether adding safety features will result in a weapon system

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<sup>46</sup> See Article 57 of Protocol I, *supra* note 14.

<sup>47</sup> The use of a weapon system that inflicts greater civilian casualties and would provide no additional advantage to the user militarily when another system is readily available also contravenes one of the primary motivating doctrines in arms control. The first modern arms control treaty, The St. Petersburg Declaration of 1868, stated that nations are prohibited from "the employment of arms which uselessly aggravate the sufferings of disabled men, or render their death inevitable." While this rule has always been directed at the prohibition of weapons which cause unnecessary suffering amongst their targets (such as expanding bullets, barbed lances, poison, etc.), it also puts forward a strong principle: that it is not permissible to employ weapons with no military advantage over alternatives that would decrease human suffering. Declaration Renouncing the Use, in Time of War, of Certain Explosive Projectiles Under 400 Grammes Weight (St. Petersburg Declaration), Dec. 11, 1868, 138 Consol. T.S. 297 (1868-69).

<sup>48</sup> We have chosen to avoid an evaluation of cost on a "per weapon basis" because such an analysis fails to account for quantity versus quality tradeoffs. This is a particular problem in the area of AFVs, where militaries may be choosing between using a single, highly advanced AFV to penetrate an enemy's defenses, or a swarm of disposable AFVs to overwhelm them. Evaluating these systems at the level of individual units risks ignoring the military maxim, "Quantity has a quality all its own."

too expensive for deployment. In contrast, a budgetary model calculates how much a country could feasibly spend on its military.

1. An Evaluation of the Budgetary Model Analysis

The easiest way to construct a budgetary model would be to calculate how much a country could feasibly spend on its military based on a percentage of its gross domestic product (GDP).<sup>49</sup> After arriving at this number for a country, one would then subtract the amount that it is currently spending on its military (Feasible Military Spending – Current Military Spending = X). If the cost of a safety feature is less than X, then it is feasible for that country to purchase it.

The problem with a budgetary model frame is that it produces skewed results. The countries most affected would be those with low expenditures on their militaries relative to their GDP, likely due to a lack of serious military threats.<sup>50</sup> As a result, the countries predicted to make the most additional expenditures relative to their economies would be the ones least likely to create civilian casualties, since they are unlikely to take part in any military actions. It also has the perverse effect of causing those countries to drive up military spending to the required level, when they may prefer to use those funds for health and safety purposes. Thus, the budgetary model might cost more lives than it saves.<sup>51</sup>

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<sup>49</sup> One method could be to find the median percentage of GDP spent on military expenditures and set that as the required amount. In 2013, this was 2.3%. *Military Expenditure (% of GDP)*, WORLD BANK, <http://data.worldbank.org/indicator/MS.MIL.XPND.GD.ZS> [https://perma.cc/BJF5-V35P]. Other possible methods include looking at the regional median or even the national historical median in order to determine the proper level of spending. Finally, national practice, as incorporated in international agreements, could be used as a guide. For example, NATO's requirement that member states spend at least two percent of their GDP on defense). See North Atlantic Treaty Organization, *Funding NATO*, [http://www.nato.int/cps/en/natohq/topics\\_67655.htm](http://www.nato.int/cps/en/natohq/topics_67655.htm) [https://perma.cc/7PZ6-H3WM].

<sup>50</sup> *Military Expenditure*, *supra* note 49.

<sup>51</sup> To illustrate this point, consider the following hypothetical about Canada. It spent one percent of its GDP of \$1.827 trillion U.S.D. in 2013 on military expenditures. *Data: Canada*, WORLD BANK, <http://data.worldbank.org/country/canada> [https://perma.cc/VMQ5-2PWR]. For the sake of argument, let us assume that the median military spending, 2.3% of GDP in 2013 according to the World Bank, is the benchmark of feasibility. *Military Expenditure*, *supra* note 49. In that case, the feasibility requirements would require Canada to raise its military expenditures by 130%, or by 23.75 billion dollars. If Canada stays within its current budget of 276.3 billion, this would require massive cuts to many social programs and likely result in more total deaths than those saved by the expenditures on weapon safety measures. In comparison, the Canadian Federal Government transfers 44.2 billion

## 2. Evaluation of the Cost-Per-Life-Saved Analysis

As a result of these distortions, we propose that any evaluations of feasibility under the Law of Armed Conflict standards be conducted at the weapons system level using the “Cost-Per-Life-Saved” model. A Cost-Per-Life-Saved model takes the cost of the safety feature and divides it by the estimated number of lives saved. To understand the Cost-Per-Life-Saved model, consider the following hypothetical. A country is planning to purchase 1,000 drones for ten billion dollars. These drones come with one of two different sensor systems. Sensor System A has a superior ability to distinguish between civilians and combatants; it is estimated that using Sensor System A will result in 100 less civilian casualties over the lifetime of the drone fleet. However, a fleet utilizing Sensor System A will cost an additional three billion dollars.

In the drone fleet hypothetical, Sensor System A has a cost per life of 30 million dollars (3 billion dollars divided by 100 lives equals 30 million dollars). The problem is determining whether this cost per life is unfeasibly excessive.

The primary advantage of the Cost-Per-Life-Saved Model is that a working system already exists with a methodology for determining when the cost per life is excessive. In the United States, federal agencies such as the Department of Transportation and the Environmental Protection Agency regularly make Cost-Per-Life-Saved calculations to determine whether or not to impose regulations to mandate certain safety features.<sup>52</sup> For example, in 2005, the Department of Transportation (DOT) considered a proposal to require car companies to double the strength of car roofs in order to reduce deaths in rollover accidents.<sup>53</sup> The DOT estimated that this change would save 135 lives and prevent 1,065 nonfatal injuries per year.<sup>54</sup> However, based upon its calculations, this would cost between 376 and 824 million dollars more than the

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dollars to other levels of government to support the public Health System. Jordan Press, *The 2014 Federal Budget by the Numbers: The Nitty Gritty of this Year's Budget*, CANADA.COM (Feb. 11, 2014), <http://o.canada.com/news/national/the-2014-federal-budget-by-the-numbers> [<https://perma.cc/MF3Y-GEB7>].

<sup>52</sup> As part of the economic analysis required by Executive Order 12866, federal agencies are required to place a monetary value on the expected health benefits of health, safety, and environmental regulations which are designed to reduce the risk of injury. CURTIS W. COPELAND, CONG. RESEARCH SERV., R41140, HOW AGENCIES MONETIZE “STATISTICAL LIVES” EXPECTED TO BE SAVED BY REGULATIONS (2010).

<sup>53</sup> *Id.* at 20. The DOT has a conversion factor that values each nonfatal injury as the equivalent of 5.2% of a fatality, meaning that the regulation would prevent 190 fatality equivalents.

<sup>54</sup> *Id.*



value of the lives saved per year.<sup>55</sup> Consequently, the DOT chose a less stringent regulation.<sup>56</sup> These calculations are typically made by agencies engaging in a cost-benefit analysis of a new policy or regulation that may affect public health across a wide population. In fact, the Environmental Protection Agency has used these methods since the 1980s.<sup>57</sup> Regulators in other countries employ similar calculations.<sup>58</sup>

When these entities attempt to balance the costs and benefits of a particular policy, they use the “value of the statistical life,” or VSL, to determine whether a policy is appropriate or too burdensome to implement.<sup>59</sup> The VSL is calculated using surveys and data that measure an individual’s willingness to accept marginal levels of increased risk of death in exchange for a monetary advantage.<sup>60</sup> Economists have focused on specific types of market decisions that involve these implicit trade-offs to develop estimates of the value of a statistical life.<sup>61</sup> While there are several techniques for arriving at the value of a statistical life, the primary method is measuring an individual’s willingness to pay to reduce a small risk of dying.<sup>62</sup> Economists rely upon measurements of differential compensation for on-the-job risk in labor markets, for example, as a proxy for how much an employee needs to be paid to accept a slightly riskier job.<sup>63</sup>

Importantly, because the value of a statistical life is measured using data from the labor market of a specific

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<sup>55</sup> Federal Motor Vehicle Safety Standards; Roof Crush Resistance; Phase-In Reporting Requirements, 74 Fed. Reg. 22,348 (May 12, 2009).

<sup>56</sup> *Id.*

<sup>57</sup> U.S. ENVTL. PROT. AGENCY: NAT’L CTR. FOR ENVTL. ECON., FREQUENTLY ASKED QUESTIONS ON MORTALITY RISK VALUATION (2015), <http://yosemite.epa.gov/ee/epa/eed.nsf/pages/MortalityRiskValuation.html> [<https://perma.cc/QFF6-WSZM>].

<sup>58</sup> See Vincent Biousque, *The Value of Statistical Life: A Meta-Analysis* (Organization for Economic Co-operation and Development Working Paper on National Environmental Policies) (Jan. 30, 2012), [http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/EPOC/WPNEP\(2010\)9/FINAL&doclanguage=en](http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/EPOC/WPNEP(2010)9/FINAL&doclanguage=en) [<https://perma.cc/7UWC-R8EX>].

<sup>59</sup> *Id.*

<sup>60</sup> For a detailed mathematical analysis of the calculations made to derive the value of a statistical human life from labor market data, see W. Kip Viscusi & Joseph E. Aldy, *The Value of a Statistical Life: A Critical Review of Market Estimates Throughout the World* 4-7 (Harvard Law School John M. Olin Center for Law, Economics and Business Discussion Paper Series, Paper 392) (2002), [http://lsr.nellco.org/harvard\\_olin/392](http://lsr.nellco.org/harvard_olin/392) [<https://perma.cc/R9GP-P5QJ>].

<sup>61</sup> *Id.* at 1-2.

<sup>62</sup> *Id.*

<sup>63</sup> *Id.* at 4-7.

country, the VSL varies between nations.<sup>64</sup> This range of outcomes raises the question of which VSL a combatant ought to use when considering a weapon system.<sup>65</sup>

### 3. Civilian Lives Should Be Valued Based Upon the VSL of the Citizens of the Country Deploying the Weapon

We propose that in any calculations involving a trade-off between civilian lives and cost of a safety feature, a combatant should be required to use the VSL of its own citizens. This rule is predictable and tracks closely with the feasibility requirement of Additional Protocols Article 57.2(a). First, requiring a nation to use its own citizens' lives as a measurement of value avoids neocolonial discounting of the lives of civilians in the targeted area, which would allow less care when targeting citizens of poorer nations.<sup>66</sup> That concept facially violates the U.N. Charter and numerous human rights treaties.<sup>67</sup> Second, VSL closely tracks the overall wealth of a

<sup>64</sup> Biauxque, *supra* note 58, at 14.

<sup>65</sup> It should be noted that this analysis only involves targeting under certain weapon systems and does not abrogate responsibility under applicable general principles.

<sup>66</sup> For example, Biauxque cites a study conducted in 2006 pegging the average value of a statistical life in Bangladesh at 5,248 U.S. dollars; while in 2010, the EPA set the value of the statistical human life at 9.1 million dollars. As a result, a country would need to spend 1733 times more to preserve a human life while operating in the U.S. than when operating in Bangladesh. Biauxque, *supra* note 58, at 14; Binyamin Appelbaum, *As U.S. Agencies Put More Value on a Life*, *Businesses Fret*, N.Y. TIMES, Feb. 16, 2011, <http://www.nytimes.com/2011/02/17/business/economy/17regulation.html> [<https://perma.cc/G9QR-JQC9>].

<sup>67</sup> The United Nations Charter specifically establishes the principle of "equal rights and self-determination of peoples." U.N. Charter, art. I, ¶ 2. Furthermore, several key International Humanitarian treaties specify that certain rights cannot be restricted based on an individual's national or social origin, or property. *See* The International Covenant on Civil and Political Rights art. II, Dec. 16, 1966, 999 U.N.T.S. 171; The International Convention on Economic, Social, and Cultural Rights art. II, Dec. 16 1966, 993 U.N.T.S. 3. Additionally, the crime against humanity of prosecution focuses on selective punitive acts that discriminate along racial religious or political lines. *See* Prosecutor v. Naletilic and Martinovic, Case No. IT-95-16-T, Judgement ¶ 634 (Int'l Crim. Trib. for the Former Yugoslavia Mar. 31, 2003), [http://www.icty.org/x/cases/naletilic\\_martinovic/tjug/en/nal-tj030331-e.pdf](http://www.icty.org/x/cases/naletilic_martinovic/tjug/en/nal-tj030331-e.pdf) [<https://perma.cc/DU64-6LNS>] ("The following elements must be proven to establish that persecution as a crime against humanity has been committed: (i) The perpetrator commits a discriminatory act or omission; (ii) The act or omission denies or infringes upon a fundamental right laid down in international customary or treaty law; (iii) The perpetrator carries out the act or omission with the intent to discriminate on racial, religious or political grounds; (iv) The general requirements for a crime against humanity pursuant to Article 5 of the Statute are met."); *see also* Prosecutor v. Kupresic et al., Case No. IT-95-

nation.<sup>68</sup> As a result, countries with more wealth will be required to spend more on avoiding civilian casualties than poorer nations. Finally, there is a predictability benefit: military planners can always be certain of the relevant VSL calculation when developing a weapon system.

#### 4. Feasibility Evaluations May Vary by Battlespace and Commanders Are Not Responsible for Incorrect, Good-Faith Evaluations of Feasibility

While a military cannot shift its valuation of human life based on regional wealth, the location of hostilities may affect an AFV's feasibility evaluation. For example, the concentration of civilians may vary in unexpected battlespaces. If military planners have developed an arsenal predicated on the belief that they will need to face a very large enemy force in a region with a minimal civilian population (*e.g.*, Saudi Arabian military planners anticipating an invasion from Iraq), then their calculations will require far fewer safety measures than if they were fighting an enemy in urban areas.<sup>69</sup> However, because of the lag between the start of a conflict and the re-equipping of armed forces, a military could unexpectedly be forced to deploy weapons in a region where deployment would not have been considered legal prior to the conflict.

U.S. Secretary of Defense Donald Rumsfeld famously stated, "You go to war with the army you have, not the army you might want or wish to have at a later time."<sup>70</sup> The trial of Generaloberst Lothar Rendulic demonstrates that the "fog of war" can serve as a legitimate defense against charges of war crimes.<sup>71</sup> Military planners cannot always predict the location

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16-T, Judgement ¶ 615 (Int'l Crim. Trib. for the Former Yugoslavia Jan. 14, 2000), <http://www.icty.org/x/cases/kupreskic/tjug/en/kup-tj000114e.pdf> [<https://perma.cc/5GGJ-C57P>] ("Persecution can also involve a variety of other discriminatory acts, involving attacks on political, social, and economic rights.").

<sup>68</sup> Biaisque, *supra* note 58, at 14.

<sup>69</sup> As civilian density decreases, the probability of hitting a civilian with an errant shot decreases. Thus, under the Cost-Per-Life-Saved Model, a weapon system upgrade that improves accuracy would be justified in a densely populated setting where it could save 100 lives, but it would not be in a scarcely populated setting, where it would only save 10 lives.

<sup>70</sup> *Troops Put Rumsfeld in the Hot Seat*, CNN (Dec. 8, 2004), <http://www.cnn.com/2004/US/12/08/rumsfeld.kuwait/index.html> [<https://perma.cc/XV8A-WS6F>].

<sup>71</sup> In 1944 Rendulic was the German Armed Forces Commander North, which included Nazi forces in Norway. Following the retreat of three Army Corps from Finland with Soviet troops in hot pursuit, Rendulic ordered the implementation of a scorched-earth policy in the province of Finmark, including the forcible evacuation of the civilian inhabitants, the destruction of roads and bridges, communication lines, port facilities, and civilian housing. He was charged with the destruction and seizure of

and nature of future armed conflict; their choices in equipping their military forces must be judged on the basis of whether they “acted within the limits of honest judgment on the basis of conditions prevailing at the time.”<sup>72</sup> Liability, however, could emerge if commanders fail to take reasonable steps to reconfigure their arsenals and supply chain once the nature of the conflict becomes apparent.<sup>73</sup>

#### IV. Effect of the Economic Costs of Compliance Systems on the Design of AFVs

These feasibility and economic concerns affect the strategic choices made in the design of AFVs. Costs can be fixed across the entire weapon system or there can be incremental costs that increase in each unit produced, thereby creating different pressures on designers.

##### A. *Role of Individual Vehicle Costs on the Design of AFVs*

One of the key programming calculations is the balance between the AFV's survival and avoidance of civilian casualties, particularly where the threat to the AFV is ambiguous.

Consider two possible AFVs. One is a \$100,000 sentry unit guarding a checkpoint, and the second is a \$100,000,000 advanced AFV located at an identical checkpoint. Each unit is approached by a civilian vehicle that does not respond to instructions and which may contain a bomb. The longer the AFV gives the civilian vehicle to respond to its instructions, the more likely it is that a bomb will succeed in destroying the AFV. Because no soldiers are present to be killed by a blast, there is no human self-defense justification for shooting the

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enemy property in violation of The Hague Regulations Article 23(g), which prohibits “the destruction or seizure of enemy property except in cases where this destruction or seizure is urgently required by the necessities of war.” Rendulic justified his actions on the grounds that these measures were justified by the military necessity of protecting his retreating forces from Soviet troops. At the time of trial, it was clear that “there is evidence on record that there was no military necessity for this destruction and devastation,” as the Soviets had halted their advance. However, the court acquitted Rendulic of the charge on the grounds that “the conditions, as they appeared to the defendant at the time were sufficient upon which he could honestly conclude that urgent military necessity warranted the decision made.” U.S. v. Wilhelm List (“The Hostage Case”) XI TWC 1113 (1948).

<sup>72</sup> *Id.*

<sup>73</sup> For example, the use of weapons which may be justified at the start of a conflict may not be justified several years into a conflict because sufficient time has passed for the military to feasibly deploy more compliant weapon systems.

vehicle. Instead, the determination to fire must be justified under the military necessity to protect friendly lives and combat resources. The cost and ability to replace the AFV will dictate the level of leniency granted to the driver of the approaching vehicle. As such, under these hypothetical circumstances and assuming equal vulnerability ranges, the \$100,000,000 AFV must be programmed to open fire sooner than the \$100,000 unit.

Allowing more valuable AFVs more leeway in opening fire on potential threats can be justified under the principles of proportionality, which holds that “loss of life and damage to property must not be out of proportion to the military advantage to be gained, and of military necessity which permits only that use of force required to achieve a legitimate military goal.”<sup>74</sup> Here, the military advantage and necessity is the preservation of the AFV for combat operations. Since the loss of the more expensive AFV depletes more national military resources, these principles permit the use of more robust measures to preserve it.<sup>75</sup>

Under the feasibility standard, combatants might prefer disposable AFVs given their greater leeway in circumstances involving civilians. In contrast, however, economic costs and other tactical and strategic considerations support more centralized and expensive AFVs. Assuming a non-swarmling system,<sup>76</sup> each individual AFV will require a sensor system and a computer capable of processing the sensor’s input and making decisions based on that input. A combatant who spends a similar percentage of a unit’s procurement budget on sensors and computing systems in both small procurements of expensive AFVs and mass procurements of more disposable units will be able to afford more advanced sensor and computing systems in the lower-production-run unit.<sup>77</sup>

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<sup>74</sup> U.S. DEP’T OF ARMY, FIELD MANUAL 27-10, *supra* note 16, at 19.

<sup>75</sup> Although the deploying power may be under some concomitant obligation not to unnecessarily expose the high-value AFV for inconsequential purposes.

<sup>76</sup> Swarm Robotics can be defined as “the study of robotic systems consisting of large groups of relatively small and simple robots that interact and cooperate with each other in order to jointly solve tasks that are outside their own individual capabilities.” Frederick Ducatelle et al., *Self-organized Cooperation Between Robotic Swarms*, 5 SWARM INTELLIGENCE 73, 74 (2011). By virtue of communication between members of the swarm, the swarm is able to perform calculations and feats of which individual members are not capable, meaning that it is not necessary for each individual component of the swarm to have highly advanced processing systems or sensors. *Id.*

<sup>77</sup> For instance, consider two separate procurements of ten billion dollars each. The first procurement is for five Autonomous Naval Destroyers at two billion dollars each. The second procurement is for one thousand

The military procurer's task is uneasy. While recent U.S. experience favors a qualitative edge in conventional war,<sup>78</sup> other conventional examples<sup>79</sup> and unconventional warfare scenarios<sup>80</sup> demonstrate the value of quantitative superiority. In particular, numerosity is valuable where the battlespace requires extensive deployments of small units over a wide geography to defend the populace and deny opponents access to resources.

*B. Role of System-Wide Costs in Effecting AFV Design*

In contrast to sensors and computing power, software and research and development are fixed costs for a weapon system, regardless of the number of units created. Based upon the current costs for drone vehicles, one can anticipate that the general cost of research and development will account for approximately 20% of the total weapon system procurement cost.<sup>81</sup> The research and development costs per system can be lowered significantly by allocating them across multiple weapon systems rather than creating a unique platform for each system.

The U.S. military is currently considering this model. In 2012, the Defense Science Board recommended separating the procurement of autonomous systems from the acquisition of vehicle platforms. This separation would allow for the

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autonomous swarming naval escort vehicles at ten million dollars each. If 20% of the budget is designated for sensors and computing resources, then the budget for those systems will be two million dollars in each of the small boats in comparison with four hundred million in the case of each destroyer.

<sup>78</sup> See ANNIE JACOBSEN, *THE PENTAGON'S BRAIN: AN UNCENSORED HISTORY OF DARPA, AMERICA'S TOP-SECRET MILITARY RESEARCH AGENCY* 27 (2015).

<sup>79</sup> World War Two is an example, where U.S. production of transport ships, bombers, and tanks simply overwhelmed any German qualitative edge. JOHN ELLIS, *BRUTE FORCE, ALLIED STRATEGY AND TACTICS IN THE SECOND WORLD WAR* 18, 266 (1990).

<sup>80</sup> See Vietnam and post-2003 Iraq for examples. See JACOBSEN, *supra* note 78, at 133-34.

<sup>81</sup> This percentage was arrived at using figures from the U.S. Government Accountability Office disclosing the total procurement costs and research and development costs of a range of weapon systems. The authors calculated the total funding to complete procurement of all vehicles listed as unmanned and then divided this by the total research and development costs of those units. These units included: MQ-1C Grey Eagle, MQ-4C Triton, MW-8 Fire Scout, MQ-9 Reaper, RQ-4 A/B Global Hawk. Note that these figures do not include weapons systems still under the "black budget" and not fully disclosed to the public, which may have a different balance of research and development versus procurement costs. U.S. GOV'T ACCOUNTABILITY OFF., *GAO-140340SP, DEFENSE ACQUISITIONS: ASSESSMENTS OF SELECTED WEAPON PROGRAMS* (2014).

deployment of a single version of autonomy software across platforms, rather than requiring a new artificial intelligence (AI) for each.<sup>82</sup>

In 2008, the U.S. government was responsible for 80% of research funding into artificial intelligence in the United States.<sup>83</sup> There is evidence that this dynamic is changing rapidly as more corporations understand the commercial possibilities of drones and autonomous vehicles.<sup>84</sup> Off-the-shelf

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<sup>82</sup> U.S. DEP'T OF DEF., TASK FORCE REPORT: THE ROLE OF AUTONOMY IN DoD SYSTEMS 12 (2012), <http://www.fas.org/irp/agency/dod/dsb/autonomy.pdf> [<https://perma.cc/M8UV-AQLE>].

<sup>83</sup> SINGER, *supra* note 12, at 78.

<sup>84</sup> An excellent example of this shift has occurred in the research and development of self-driving cars. The Defense Advanced Research Project Agency helped to kick-start the field through a series of three “Grand Challenges.” In these challenges outside teams competed to complete an increasingly difficult set of courses with autonomous vehicles in order to win cash prizes. These challenges took place in 2004, 2005, and 2007 and witnessed an extraordinary growth in the capabilities of the cars. In the initial 2004 contest no car managed to go more than seven miles of the planned 142 mile course in a empty desert environment. By the final race, teams had managed to complete a 132 mile course as well as navigate a complex course in a city environment while negotiating other moving traffic and obeying traffic regulations. *The DARPA Grand Challenge: Ten Years Later*, DARPA (Mar. 13, 2014), <http://www.darpa.mil/news-events/2014-03-13> [<https://perma.cc/RFP4-YQUD>]. This in turn triggered a wave of commercial research in the area. See, e.g., *What We’re Driving At*, GOOGLE OFFICIAL BLOG (Oct. 9, 2010), <http://googleblog.blogspot.com/2010/10/what-were-driving-at.html> [<https://perma.cc/B5WQ-9TLA>] (announcing the Google self-driving car research project and noting the DARPA Challenge pedigree of its technical team members). While fully autonomous cars are not yet commercially available, companies such as Tesla offer autopilot features which increasingly automate driving tasks, including steering to stay within a lane and managing speed based on surrounding traffic and speed limits. See *Dual Motor Model S and Autopilot*, TESLA BLOG (Oct. 10, 2014), <http://www.teslamotors.com/blog/dual-motor-model-s-and-autopilot> [<https://perma.cc/CA9Q-55P9>]. In 2015, several major car companies made dueling press announcements stating their intention to produce fully self-driving cars for the commercial market in the next several years. See, e.g., Alex Davies, *I Rode 500 Miles in a Self-Driving Car and Saw the Future. It’s Delightfully Dull*, WIRED (Jan. 7, 2015), <http://www.wired.com/2015/01/rode-500-miles-self-driving-car-saw-future-boring> [<https://perma.cc/7GP8-LRJ2>] (Audi had reporters drive a self-driving car model to the 2015 Consumer Electronics Show and stated that the technology will be in production cars within 3-5 years.). However, it should be noted that despite the fast pace of progress, a significant wait exists before truly autonomous vehicles will be commercially available. Bryant Walker Smith, *A Legal Perspective on Three Misconceptions in Vehicle Automation*, in ROAD VEHICLE AUTOMATION 85 (Gereon Meyer & Sven Beiker eds., 2014) (“Automotive experts recognize that the path from research to product is long—and that there is a tremendous difference between, on one hand, a research system that well-trained technicians carefully maintain, update, and operate exclusively on certain roads in certain conditions and, on the

purchases, as in other government procurement areas, present a cost-effective alternative.<sup>85</sup>

In the purely AI space, companies are making significant investments in artificial intelligence interfaces with their systems. These include well-publicized projects such as the Watson computer, created by IBM to win the television show Jeopardy, which is now being used commercially to guide decisions on drug regimens for cancer patients.<sup>86</sup> As more corporations fund research on autonomy in their efforts to develop commercial products, military developers will be able to supplement their own designs for more compliant AFV autonomy systems.<sup>87</sup>

Procurement experience demonstrates that government costs decrease as technology is disseminated.<sup>88</sup> The legal implications of cheaper technology include: 1) an increased obligation to incorporate AI into a broader spectrum of weapons; 2) an obligation to maintain an expanded inventory of smarter weapons; and, most importantly, 3) a shift in the calculus of the requirements of weapons use. As AI-controlled weapons become cheaper, smarter, and more ubiquitous, the core principles of the Law of Armed Conflict will each militate against “dumb” weapons in every environment.

## V. Recommendations for Policymakers

In light of these economic pressures and legal obligations, we have several recommendations for policymakers authorizing the development of AFV systems.

First, we recommend the development of AI that is compatible with multiple weapons systems. We also recommend the development of less expensive AFVs (or

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other hand, a production system that poorly trained consumers neglect and abuse for two decades in almost any conceivable driving scenario. For this reason, production vehicles take years to be developed, tested, and certified to a complex array of highly detailed public and private standards.”)

<sup>85</sup> AM. BAR ASS'N, GOVERNMENT CONTRACT LAW, THE DESKBOOK FOR PROCUREMENT PROFESSIONALS, ch. 11 (3d ed. 2007); W. NOEL KEYES, GOVERNMENT CONTRACTS UNDER THE FEDERAL ACQUISITION REGULATION (3d ed. 2003).

<sup>86</sup> Bruce Upbin, *IBM's Watson Gets Its First Piece of Business in Healthcare*, FORBES (Feb. 8, 2013), <http://www.forbes.com/sites/bruceupbin/2013/02/08/ibms-watson-gets-its-first-piece-of-business-in-healthcare> [https://perma.cc/YR7H-APYE].

<sup>87</sup> Similarly, cancer research may have a synergistic relationship with nano-weaponry. See Evan J. Wallach, *A Tiny Problem with Huge Implications—Nanotech Agents as Enablers or Substitutes for Banned Chemical Weapons: Is a New Treaty Needed?*, 33 FORDHAM INT'L L.J. 858 (2009-2010).

<sup>88</sup> See DESKBOOK FOR PROCUREMENT PROFESSIONALS, *supra* note 85.



cheaper subunits deployable by expensive AFVs) for use in those civilian interaction situations that require balancing the survival of machines with survival of civilian noncombatants.

Second, when regulating the development and deployment of AFVs, policymakers ought to avoid being bound by initial analyses that a fixed amount of money per safety feature is sufficient, and instead focus on the VSL of the country fielding the weapon system.

Third, we recommend the development of a military command structure that provides commanders with comprehensive logs of AFV battlefield activity. While some AFVs have the capacity to record battlefield activities, this alone is insufficient. Commanders need to access the logs in their entirety to effectively monitor subordinates.

Finally, we urge policymakers to recognize that AFVs, if made compliant with the Law of Armed Conflict, possess inherent advantages that promote more “humane” approaches to war. Although there has been widespread criticism of “killer robots,” robots are not subject to the same limitations as their human counterparts. A robot soldier will not avenge its ally’s death and is more likely to risk its own safety to avoid inflicting civilian casualties. Properly developed AFVs have the capacity to create a more compliant and principled battlefield environment.

## CONCLUSION

Autonomous fighting vehicles can already select their own targets and are gradually replacing the human soldier. Their deployment has revolutionized military affairs. Encouragingly, AFVs may eventually mitigate civilian collateral damage due to superior reaction times and dispassionate reactions in combat.

The extent to which an AFV is able to comply with the Laws of War and avoid civilian casualties will largely depend on design decisions that significantly impact the economic cost of deploying that vehicle. By evaluating AFV systems using a cost-per-death calculation based on the value of a statistical life of the deploying nation, combatants can effectively determine whether their weapon systems are compliant with the laws of war and commanders can fulfill their responsibilities. With new capabilities come new responsibilities. Balancing these factors will become increasingly important as the economic costs of replacing destroyed AFVs replaces the avoidance of casualties as a driver of rules of engagement.