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Nanotechnology and the Future of the Law of Weaponry

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CONTENTS

I. Introduction	487
II. Nanotechnology and the Law of Weaponry.....	491
III. Weapons Law Paradox	498
IV. The Potential of Nanotechnology to Bring Change to the Law of Weaponry.....	503
A. The Power to Kill or Capture Debate	504
B. The Legality of Incapacitating Chemical Agents Debate.....	509
V. Conclusion	514

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I. INTRODUCTION

Advances in nanotechnology have increasingly been facilitating novel applications in a wide range of fields including materials, electronics, photonics, biotechnology and life sciences. The ability to design and manipulate molecules with specific properties at the nanoscale level allows scientists to achieve outcomes that are of potential use in hostilities, including—but by no means limited to—increased electrical efficiency of solid-state laser weapons;¹ enhanced or tailored blast and detonation parameters of blast weapons, such as thermobaric explosives using nano-energetic composites;² miniaturization of unmanned aerial vehicles (known as “nano air vehicles,” “ultra-lightweight airborne vehicles” or “wide area search autonomous attack miniature munitions”) that can also operate collectively in a coordinated, self-organized manner with the use of swarm intelligence technology;³ and controlled, sustained delivery of biochemical agents, which could limit and regulate the spread of biochemical agents and other toxins within defined parameters.⁴

1. In April 2013 the U.S. Navy announced plans to deploy for the first time a solid-state laser weapon aboard *USS Ponce*, which has been developed through the Solid State Laser Technology Maturation Program. Jason Kelly, *Navy Unveils Its First Laser Gun*, NAVY LIFE (Apr. 10, 2013), <http://navylive.dodlive.mil/2013/04/10/solid-state-laser-gun-to-be-placed-aboard-uss-ponce/>. For information on the program, see *Solid State Laser Technology Maturation Program*, ONR (Sept. 2012), <http://www.onr.navy.mil/Media-Center/Fact-Sheets/Solid-State-Laser-Technology-Maturation-Program.aspx>.

2. DIRECTOR, DEFENSE RESEARCH & ENGINEERING, U.S. DEPARTMENT OF DEFENSE, DEFENSE NANOTECHNOLOGY RESEARCH AND DEVELOPMENT PROGRAM 6–7 (2009), available at http://www.nano.gov/sites/default/files/pub_resource/dod-report_to_congress_final_1mar10.pdf; Andrzej W. Miziolek, *Nanoenergetics: An Emerging Technology Area of National Importance*, AMPTIAC NEWSLETTER, Spring 2002, at 43, 44.

3. Press Release, U.S. Defense Advanced Research Project Agency, *Time Magazine Recognizes DARPA's Hummingbird Nano Air Vehicle* (Nov. 24, 2011), available at <http://automotive-area.blogspot.com/2011/11/time-magazine-recognizes-darpas.html> [hereinafter DARPA Press Release]; William A. Davis, *Nano Air Vehicles: A Technology Forecast* (2007), available at http://www.au.af.mil/au/awc/awcgate/cst/bh_davis.pdf. On April 14, 2015, the U.S. Office of Naval Research announced recent technology demonstrations of swarming unmanned aerial vehicles as part of the Low-Cost UAV Swarming Technology (LOCUST) program. Press Release, Office of Naval Research, *LOCUST: Autonomous, Swarming UAVs Fly into the Future* (Apr. 14, 2015), available at <http://www.onr.navy.mil/Media-Center/Press-Releases/2015/LOCUST-low-cost-UAV-swarm-ONR.aspx>.

4. See, e.g., MARGARET E. KOSAL, NANOTECHNOLOGY FOR CHEMICAL AND BIOLOGICAL DEFENSE 90–93 (2009).

While these novel applications of nanotechnology for military purposes are not specifically prohibited by any weapons treaties, the employment of the means of warfare enhanced by nanotechnology must comply with the various requirements of the law of armed conflict (LOAC). The application of the relevant rules to specific nanotechnology-enabled or -enhanced weapons, or even to conventional means of warfare in an environment where engineered nanoparticles are widely and heavily used, may pose challenges in terms of how the relevant LOAC rules should be interpreted in light of the specific characteristics of the weapon or the weapon system and its effects in the battlefield.⁵ Yet, those are the challenges that need to be—and can be—resolved through rigorous debate on the interpretation and application of relevant principles and rules in each specific context, rather than requiring or demanding changes to them. Commanders play a key role in ensuring that new technology weapons, including nanotechnology-enabled or -enhanced weapons, comply with the law when they are employed, leaving no accountability gap no matter how technologies evolve.⁶

Notwithstanding the enduring value and relevance of the LOAC principles and rules developed over several hundred years and through lessons learned from their application in armed conflict, there remains room for those principles and rules to change through State practice and agreement, often informed by technological advances and their perceived impact on the battlefield.⁷ As Michael Schmitt has most relevantly observed,

5. For details, see the author's earlier studies. Hitoshi Nasu, *Nanotechnology and the Law of Armed Conflict*, in *NEW TECHNOLOGIES AND THE LAW OF ARMED CONFLICT* 143 (Hitoshi Nasu & Robert McLaughlin eds., 2014); Hitoshi Nasu, *Nanotechnology and Challenges to International Humanitarian Law: A Preliminary Legal Assessment*, 94 *INTERNATIONAL REVIEW OF THE RED CROSS* 653 (2012); Hitoshi Nasu & Tom Faunce, *Nanotechnology and the International Law of Weaponry: Towards International Regulation of Nano-Weapons*, 20 *JOURNAL OF LAW, INFORMATION AND SCIENCE* 20 (2010).

6. Similarly, in relation to autonomous weapon systems, see Jeffrey S. Thurnher, *Examining Autonomous Weapon Systems from a Law of Armed Conflict Perspective*, in *NEW TECHNOLOGIES AND THE LAW OF ARMED CONFLICT*, *supra* note 5, at 213; Kenneth Anderson, Daniel Reisner & Matthew Waxman, *Adapting the Law of Armed Conflict to Autonomous Weapon Systems*, 90 *INTERNATIONAL LAW STUDIES* 386, 405 (2014).

7. *Cf.* Barry Kellman, *Of Guns and Grotius*, 7 *JOURNAL OF NATIONAL SECURITY LAW & POLICY* 465 (2014) (observing international law's failure to adequately appreciate the impact of explosive weapons).

“[t]echnology determines how wars can be fought.”⁸ Law, on the other hand, determines how wars *should* be fought, which necessarily interacts with *how wars can be fought* as it changes with the introduction of new technologies onto the battlefield. This article considers the potential of military applications of nanotechnology to drive changes to the existing law, with specific focus on its ability to produce more sophisticated, miniaturized and tailored weapons and weapon systems that enable mechanical precision of strikes with no or few civilian casualties. To that end, it critically revisits the fundamental rationales—particularly military necessity and humanity—underpinning various principles and rules of weapons law, questioning whether and to what extent the existing balancing of those fundamental rationales can withstand pragmatic changes introduced by nanotechnology.

In order to avoid unnecessary academic discussion of unlikely hypotheticals for the purpose of pure academic interest, this article proceeds with two important limitations on the premise upon which the analysis is developed: technological feasibility (at least in a foreseeable future) and practical utility. There are many wild speculations about what nanotechnology may enable us to produce—such as autonomous, self-replicating “nano-bots” (nano-scale machines) and micro-fusion nuclear weapons—however, it is doubtful whether these are technologically feasible within the period addressed in this article.⁹ Scientists are indeed working towards miniaturization of unmanned aerial vehicles, as demonstrated by the United States’ Defense Advanced Research Project Agency’s “nano air vehicles” program,¹⁰ yet further miniaturization to micro- or nano-sized robots is at least a few decades away. The development of artificial intelligence is making parallel progress, yet it will take decades before autonomous weapon systems will be capable of compliance with targeting law requirements,¹¹ and even longer for it to be miniaturized to a size that is sufficiently small to be installed on “nano-bots” to enable their autonomous operation.

8. Michael N. Schmitt, *War, Technology and the Law of Armed Conflict*, in *THE LAW OF WAR IN THE 21ST CENTURY: WEAPONRY AND THE USE OF FORCE* 137, 137 (Anthony M. Helm ed., 2006) (Vol. 82, U.S. Naval War College International Law Studies).

9. For a physicist’s perspective, see JÜRGEN ALTMANN, *MILITARY NANOTECHNOLOGY: POTENTIAL APPLICATIONS AND PREVENTIVE ARMS CONTROL* 27–31, 100–101 (2006).

10. DARPA Press Release, *supra* note 3.

11. 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 *INTERNATIONAL REVIEW OF THE RED CROSS* 483, 491 (2012).

Even if these were technologically feasible options, the actual employment of those weapons in the way that commentators are speculating may not be practically viable. For example, weaponization of artificial intelligence with the capacity to operate beyond pre-programmed parameters through autonomous learning now appears to be feasible.¹² However, employing autonomous weapon systems that independently operate beyond pre-programmed parameters may not practically serve the interest of the commanders, who would rather use them to gather high fidelity information in order to permit reassessment of constantly changing situations, and in a manner that ensures they operate exactly as commanders direct to support the achievement of specific military objectives.

With these two limitations in mind, this article first explains how the existing principles and rules of weapons law regulate military applications of nanotechnology in light of the specific characteristics of the weapons that will be enabled or enhanced by the use of nanotechnology. Second, it examines the transformative impact of nanotechnology-enabled or -enhanced weapons on existing weapons law. In doing so, it dissects the law into its constitutive elements of military necessity and humanity, while identifying two different understandings of humanity: one concerning the protection of civilians from armed attack and the other concerning the protection of lawful targets from certain means and methods of warfare. Third, it further explores the potential of nanotechnology to drive a change to existing weapons law by contextualizing this question against two aca-

12. See, e.g., Volodymyr Mnih et al., *Human-Level Control through Deep Reinforcement Learning*, 518 NATURE 529 (Feb. 26, 2015), <http://www.nature.com/nature/journal/v518/n7540/full/nature14236.html>. The potential development of this capability raises concerns for its ability to comply with the targeting law requirements under the law of armed conflict and also for a potential accountability gap. See, e.g., Marco Sassóli, *Autonomous Weapons and International Humanitarian Law: Advantages, Open Technical Questions and Legal Issues to be Clarified*, 90 INTERNATIONAL LAW STUDIES 308 (2014); Tim McFarland & Tim McCormack, *Mind the Gap: Can Developers of Autonomous Weapons Systems be Liable for War Crimes?*, 90 INTERNATIONAL LAW STUDIES 361 (2014); Chantal Grut, *The Challenge of Autonomous Lethal Robotics to International Humanitarian Law*, 18 JOURNAL OF CONFLICT & SECURITY LAW 5 (2013); David Akerson, *The Illegality of Offensive Lethal Autonomy*, in INTERNATIONAL HUMANITARIAN LAW AND THE CHANGING TECHNOLOGY OF WAR 65 (David Saxon ed., 2013); Markus Wagner, *Autonomy in the Battlespace: Independently Operating Weapon Systems and the Law of Armed Conflict*, in *id.* at 99; Hin-Yan Liu, *Categorization and Legality of Autonomous and Remote Weapons Systems*, 94 INTERNATIONAL REVIEW OF THE RED CROSS 627 (2012). Cf. 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 (2013) (warning against analysis based on unfounded assumptions).

demic debates that have recently taken place: one on the power to kill or capture and another on the legality of incapacitating chemical agents.

It concludes with the finding that nanotechnology challenges a fundamental assumption that reducing civilian casualties makes warfare more “humane,” which has long supported—and sometimes hindered—the development of the principles and rules of weapons law, while highlighting practical considerations that have the potential to lead to the creation of new principles and rules.

II. NANOTECHNOLOGY AND THE LAW OF WEAPONRY

Any military application of new technologies is subject to the well-established principle under the law of armed conflict that “[i]n any armed conflict, the right of the Parties to the conflict to choose methods or means of warfare is not unlimited.”¹³ This principle is further elaborated through various rules of weapons law with express restrictions on the choice of weapons (means of warfare), which is the focus of this article, as well as on the way in which weapons are employed (methods of warfare).¹⁴ The way in which the choice of weapons or means of warfare is restricted is twofold: the general, principle-based approach and the more specific, rule-based approach. The general principles of weapons law prohibit:

13. Protocol Additional to the Geneva Conventions of 12 August 1949, and Relating to the Protection of Victims of International Armed Conflicts art. 35(1), June 8, 1977, 1125 U.N.T.S. 3 [hereinafter Additional Protocol I]. See also Regulations Respecting the Laws and Customs of War on Land art. 22, annexed to Convention No. IV Respecting the Laws and Customs of War on Land, Oct. 18, 1907, 36 Stat. 2227, T.S. No. 539, reprinted in DOCUMENTS ON THE LAWS OF WAR 73 (Adam Roberts & Richard Guelff eds., 3d ed. 2000) [hereinafter Hague Regulations]. Judge Weeramantry elaborated on the multicultural traditions underpinning limitations to the conduct of warfare in his dissenting opinion in the *Legality of Nuclear Weapons* advisory opinion. See *Legality of the Threat or Use of Nuclear Weapons*, 1996 I.C.J. 226, 478–82 (Weeramantry, J. dissenting) (July 8) [hereinafter *Legality of Nuclear Weapons*].

14. See generally International Committee of the Red Cross, *A Guide to Legal Review of New Weapons, Means and Methods of Warfare*, 88 INTERNATIONAL REVIEW OF THE RED CROSS 931, 937 (2006); TALINN MANUAL ON THE INTERNATIONAL LAW APPLICABLE TO CYBER WARFARE 142 (Michael N. Schmitt ed., 2013).

- the employment of “weapons, projectiles and material and methods of warfare of a nature to cause superfluous injury” or “calculated to cause unnecessary suffering”;¹⁵
- the use of weapons that indiscriminately affect both lawful targets and civilians;¹⁶ and
- the employment of “methods or means of warfare which are intended, or may be expected, to cause widespread, long-term and severe damage to the natural environment.”¹⁷

In addition, States have agreed in a variety of international treaties to specific and express prohibitions of weapons, including the employment of projectiles of a weight below 400 grammes that are explosive or charged with fulminating or inflammable substances;¹⁸ expanding bullets;¹⁹ asphyxiating, poisonous or other gases;²⁰ biological weapons;²¹ chemical weapons;²²

15. Convention No. II with Respect to the Laws and Customs of War on Land art. 23(e), July 29, 1899, 32 Stat. 1803, T.S. No. 403; Hague Regulations, *supra* note 13, art. 23(e). Although the authentic French text remained the same (*maux superflus*), the identical phrase in the two instruments was translated differently. For the English translation of the treaty texts, see JAMES BROWN SCOTT, THE HAGUE CONVENTIONS AND DECLARATIONS OF 1899 AND 1907 116 (1915). Article 35(2) of Additional Protocol I placed those two expressions side by side. *See also* 1 JEAN-MARIE HENCKAERTS & LOUISE DOSWALD-BECK, CUSTOMARY INTERNATIONAL HUMANITARIAN LAW r. 70 (2005).

16. Additional Protocol I, *supra* note 13, art. 51(4); HENCKAERTS & DOSWALD-BECK, *supra* note 15, r. 71.

17. Additional Protocol I, *supra* note 13, art. 35(3).

18. 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, *reprinted in* DOCUMENTS ON THE LAWS OF WAR, *supra* note 13, at 54 [hereinafter St. Petersburg Declaration].

19. Declaration (IV, 3) Concerning Expanding Bullets, July 29, 1899, 187 Consol. T.S. 459, 26 Martens Nouveau Recueil (ser. 2) 1002, *reprinted in* DOCUMENTS ON THE LAWS OF WAR, *supra* note 13, at 64.

20. Declaration (IV, 2) on the Use of Projectiles the Object of Which is the Diffusion of Asphyxiating or Deleterious Gases, July 29, 1899, 187 Consol. T.S. 453, 26 Martens Nouveau Recueil (ser. 2) 998, *reprinted in* DOCUMENTS ON THE LAWS OF WAR, *supra* note 13, at 60; Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare, June 17, 1925, 94 L.N.T.S. 65, *reprinted in* DOCUMENTS ON THE LAWS OF WAR, *supra* note 13, at 158.

21. Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction, Apr. 10, 1972, 1015 U.N.T.S. 163, *reprinted in* 11 INTERNATIONAL LEGAL MATERIALS 309 [hereinafter BWC].

blinding laser weapons;²³ anti-personnel mines;²⁴ and, most recently, cluster munitions.²⁵

Of the three general principles, chiefly relevant to the legal consideration of nanotechnology-enabled or -enhanced weapons is the principle prohibiting superfluous injury or unnecessary suffering. As William Boothby succinctly notes, in determining the legality of a weapon with nanotechnological components, “[t]he focus will be on whether the fact that certain components are based on nanotechnology makes a significant difference to the wounding or injuring effect of the weapon or to the suffering its designed use is going to occasion.”²⁶ Yet, as discussed elsewhere, the indeterminacy and controversy over the interpretation of this principle poses significant challenges to its application for the purpose of assessing the legality of specific nanotechnology-enabled or -enhanced weapons.²⁷

The unique ability provided by nanotechnology to design and manipulate molecules with specific properties at the nanoscale level will, at least in the foreseeable future, be principally directed at miniaturizing weapons and weapons platforms; enhancing the accuracy and manipulability of precision attacks; and providing greater force protection. The focus on these programs results from the fact that weapons development in technologically developed countries is prioritized in response to the immediate needs of their military forces in existing or anticipated theaters of operation. Accordingly, the possibility of nanotechnology raising an issue with the principle prohibiting indiscriminate weapons is negligible.²⁸ Rather, nanotechnology will be found attractive in enabling existing weapons to be more discriminate by allowing mechanical precision and manipulation of attacks (for example, with miniaturized unmanned aerial vehicles or self-guiding

22. Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on Their Destruction, Jan. 13, 1993, 1974 U.N.T.S. 45, *reprinted in* 32 INTERNATIONAL LEGAL MATERIALS 800 [hereinafter CWC].

23. Protocol on Blinding Laser Weapons, Oct. 13, 1995, 1380 U.N.T.S. 370, *reprinted in* DOCUMENTS ON THE LAWS OF WAR, *supra* note 13, at 535.

24. Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on Their Destruction, Sept. 18, 1997, 2056 U.N.T.S. 211.

25. Convention on Cluster Munitions, May 30, 2008, 2688 U.N.T.S. 39.

26. WILLIAM H. BOOTHBY, CONFLICT LAW: THE INFLUENCE OF NEW WEAPONS TECHNOLOGY, HUMAN RIGHTS AND EMERGING ACTORS 183 (2014).

27. For a detailed analysis by the author, see Nasu & Faunce, *supra* note 5, at 34.

28. An exception is the use of nano-energetic composites to enhance the power of blast weapons. For the author’s analysis of the legal implications, see Nasu, *Nanotechnology and the Law of Armed Conflict*, *supra* note 5, at 146–49.

bullets with nanotechnology-enhanced sensors) or more focused application of force (demonstrated by, for instance, the solid-state laser weapon system in comparison to other types of directed energy weapons, such as the Active Denial System).²⁹ The third general principle—prohibiting weapons which are intended, or may be expected, to cause “widespread, long-term and severe damage” to the natural environment—is relevant to the extent that engineered nanoparticles may be found to have toxic effects. However, there is great uncertainty whether the dispersion of toxic engineered nanoparticles will ever satisfy the evidentiary standards necessary to establish they have caused widespread, long-term and severe damage.³⁰

On the other hand, nanotechnology, if used to develop weapons that are specifically prohibited or restricted, would be subject to the relevant weapons treaty. These treaties prohibit particular weapons or restrict their use by reference to the weapon’s construction and characteristics, unlike the weapons law principles, which tend to refer to the effects produced by the use of weapons.³¹ The definition of the prohibited weapon under these treaties tends to be so specific that any application of nanotechnology that does not meet that particular design intent will not be covered. For example, the solid-state laser weapon system is not prohibited under the 1995 Protocol on Blinding Laser Weapons, as it is not “specifically designed, as [its] sole combat function or as one of [its] combat functions, to cause

29. The Active Defense System uses millimeter waves to “zap” the surface of the skin producing intense pain without actual injury. Colin Campbell, *Raytheon Non-Lethal Heat Beam Tackles New Missions*, BREAKING DEFENSE (Nov. 5, 2013), <http://breakingdefense.com/2013/11/raytheon-non-lethal-heat-beam-tackles-new-missions/>. For legal issues concerning directed energy weapons, see, e.g., Backstrom & Henderson, *supra* note 11, at 499–502; Duncan Blake & Joseph S. Imburgia, “Bloodless Weapons”? *The Need to Conduct Legal Reviews of Certain Capabilities and the Implications of Defining Them as “Weapons,”* 66 AIR FORCE LAW REVIEW 157, 177–79 (2010); Louise Doswald-Beck & Gérald C. Cauderay, *The Development of New Anti-Personnel Weapons*, 30 INTERNATIONAL REVIEW OF THE RED CROSS 565, 573–74 (1990).

30. For details, see Nasu, *Nanotechnology and Challenges to International Humanitarian Law*, *supra* note 5, at 663–65.

31. Christopher Greenwood, *The Law of Weaponry at the Start of the New Millennium*, in THE LAW OF ARMED CONFLICT: INTO THE NEW MILLENNIUM 185, 192 (Michael N. Schmitt & Leslie C. Green eds., 1999) (Vol. 71, U.S. NAVAL WAR COLLEGE INTERNATIONAL LAW STUDIES).

permanent blindness to unenhanced vision”³² even if it were to have an effect of causing blindness.³³

By contrast, under treaties that prohibit and restrict the use of an entire class of weapons, such as the Biological Weapons Convention (BWC) and the Chemical Weapons Convention (CWC), the treaty language is broad enough to encompass and prohibit technological advances. For example, the scope of the BWC, which was adopted with the objective of “exclud[ing] completely the possibility of bacteriological (biological) agents and toxins being used as weapons,”³⁴ extends to cover a wide variety of applications of nanotechnology producing or enhancing toxic effects, as these are likely to come within the notion of “[m]icrobial or other biological agents, or toxins whatever their origin or method of production, of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes.”³⁵ Pinson argues that the Convention deals only with biological organisms or living products and therefore does not extend to the artificially or synthetically engineered products that nanotechnology would produce.³⁶ However, such a restrictive interpretation would be difficult to maintain. First, the distinction between nanotechnology and biological elements of biotechnology is artificial. High-profile accomplishments in synthetic biotechnology pose scenarios for possible construction of *de novo* biological agents without relying on naturally occurring pathogens.³⁷ Second, in addition to microbial and biological agents, Article I of the BWC

32. Protocol on Blinding Laser Weapons, *supra* note 23, art. 1.

33. WILLIAM H. BOOTHBY, WEAPONS AND THE LAW OF ARMED CONFLICT 210–11 (2009). Compare, however, with the legality of dense inert metal explosives under the 1980 Protocol on Non-Detectable Fragments, Oct. 10, 1980, 1342 U.N.T.S. 168, as discussed in Nasu & Faunce, *supra* note 5, at 33–34.

34. BWC, *supra* note 21, pmb. para. 9. Strictly speaking, the Convention does not explicitly prohibit the “use” of biological weapons, but the 1996 Fourth Review Conference confirmed that Article 1 effectively prohibits use. Fourth Review Conference of the Parties to the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction, Nov. 25–Dec. 6, 1996, Geneva, *Final Declaration of the Fourth Review Conference*, para. 3 (1996), available at http://www.un.org/disarmament/WMD/Bio/Fourth_Review.shtml.

35. BWC, *supra* note 21, art. I.

36. Robert D. Pinson, *Is Nanotechnology Prohibited by the Biological and Chemical Weapons Convention?*, 22 BERKELEY JOURNAL OF INTERNATIONAL LAW 279, 298 (2004).

37. For details, see, e.g., Gautam Mukunda, Kenneth A. Oye & Scott C. Mohr, *What Rough Beast? Synthetic Biology, Uncertainty, and the Future of Biosecurity*, 28 POLITICS AND THE LIFE SCIENCES 2 (2009); MARKUS SCHMIDT ET AL., SYNTHETIC BIOLOGY: THE TECHNO-SCIENCE AND ITS SOCIETAL CONSEQUENCES (2009).

makes an explicit reference to “toxins whatever their origin or method of production.” The *travaux préparatoires* show that Sweden sought to define toxins widely to cover all toxins of both biological and synthetic origin.³⁸ It was in this context that Sweden proposed a broad definition of toxins (which was adopted in the final text) to ensure that there would remain no loophole undermining the purpose of the Convention.³⁹ This broad definition was also confirmed in the Final Declaration of the Second Review Conference.⁴⁰ Even after the adoption of the CWC in 1993, the broad definition of toxins suggests there is no gap between the two Conventions such that no production of toxic substances through the application of nanotechnology would be unregulated.

This does not mean that any application of nanotechnology that produces or enhances toxic effects would be automatically prohibited under the BWC. The Convention only prohibits biological agents or toxins “of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes,”⁴¹ while leaving what exactly constitutes “peaceful purposes” indeterminate.⁴² In other words, the use of nanotechnology to develop or produce biological agents or toxins is not prohibited if it can be justified as being used for prophylactic, protective or other peaceful purposes. Likewise, the development of nanotechnology-assisted equipment or methods of delivery, such as encapsulation, is also lawful unless it is used for hostile purposes or in an armed conflict. The significance

38. Sweden, *Working Paper on Some Aspects of the Definition of Toxins*, U.N. Doc. CCD/333 (July 6, 1971), in OFFICIAL RECORDS OF THE DISARMAMENT COMMISSION SUPPLEMENT FOR 1971, at 46–47 (1973).

39. Conference of the Committee on Disarmament, Feb. 23, 1971–Sept. 30, 1971, *Report of the Conference of the Committee on Disarmament*, ¶¶ 49–50, U.N. Doc. DC/234 (Oct. 6, 1971), in OFFICIAL RECORDS OF THE DISARMAMENT COMMISSION SUPPLEMENT FOR 1971, at 5 (1973).

40. Second Review Conference of the Parties to the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction, Sept. 8–26, 1986, Geneva, *Final Declaration* art. I, Doc. BWC/CONF.II/13/II (Sep. 26, 1986) (reaffirming “that the Convention unequivocally applies to all natural or artificially created microbial or other biological agents or toxins whatever their origin or method of production”). See also WORLD HEALTH ORGANIZATION, PUBLIC HEALTH RESPONSE TO BIOLOGICAL AND CHEMICAL WEAPONS: WHO GUIDANCE Annex 2: Toxins, at 214–15 (2004).

41. BWC, *supra* note 21, art. I.

42. See Jack M. Beard, *The Shortcomings of Indeterminacy in Arms Control Regimes: The Case of the Biological Weapons Convention*, 101 AMERICAN JOURNAL OF INTERNATIONAL LAW 271 (2007).

of the exceptions is reinforced by Article X of the BWC, which recognizes the rights of the contracting parties to pursue the development and application of scientific discoveries and the exchange of equipment, materials and scientific and technological information for peaceful purposes.

Using nanotechnology to develop new chemical agents (whether their toxicity is proven or not), or to modify and enhance existing ones,⁴³ will more clearly fall within the purview of the CWC. The CWC aims to comprehensively ban all uses, development, production, acquisition, stockpiling, and transfer of “toxic chemicals and their precursors, except where intended for purposes not prohibited under this Convention, as long as the types and quantities are consistent with such purposes”; “munitions and devices, specifically designed to cause death or other harm through the toxic properties”; and “any equipment specifically designed for use directly in connection with the employment of [such] munitions and devices.”⁴⁴ The Convention defines “toxic chemicals” as “any chemical[s] which through [their] chemical action on life processes can cause death, temporary incapacitation or permanent harm to humans or animals . . . regardless of their origin or of their method of production,” and “precursors” as “any chemical reactant which takes part at any stage in the production by whatever method of a toxic chemical.”⁴⁵ To assist in applying verification measures, specific toxic chemicals and precursors are listed in the schedules annexed to the Convention, but the Convention prohibits all substances that come within its comprehensive definition of toxic chemicals regardless of whether they are listed in the schedules or not.⁴⁶ Like the BWC, however, the prohibition of toxic chemicals and their precursors under the CWC is not absolute, allowing chemicals used for “purposes not prohibited under this Convention”—namely, peaceful purposes (such as industrial, agricultural,

43. Ralf Trapp, *Advances in Science and Technology and the Chemical Weapons Convention*, ARMS CONTROL ASSOCIATION (Mar. 1, 2008), http://www.armscontrol.org/act/2008_03/Trapp.

44. CWC, *supra* note 22, art. II(1).

45. *Id.*, arts. II(2), II(3).

46. Walter Krutzsch & Ralf Trapp, *Article II: Definitions and Criteria*, in *THE CHEMICAL WEAPONS CONVENTION: A COMMENTARY* 73, 77 (Walter Krutzsch, Eric Myjer & Ralf Trapp eds., 2014). The delegates to Second Review Conference of the CWC States Parties, held in 2008, also considered that the existing Convention definitions were adequate to cover developments in science and technology in the application of the Convention to toxic chemicals. Conference of the States Parties, Apr. 7–18, 2008, *Report of the Second Special Session of the Conference of the States Parties to Review the Operation of the Chemical Weapons Convention (Second Review Conference)*, ¶ 9.22, Doc. RC-2/4 (Apr. 18, 2008).

research, medical, pharmaceutical), protective purposes, military purposes not connected with their use as a method of warfare, and law enforcement purposes.⁴⁷ Thus, nanotechnology-enabled chemical agents are not considered to be chemical weapons unless they are deployed with the intention to utilize the toxicity of those chemical agents.⁴⁸

It is thus clear that there is no legal gap or loophole that can be exploited with the use of nanotechnology to disguise a violation of weapons law principles or rules. These principles and rules are either broad enough to address technological advances (albeit with a degree of indeterminacy) or specific enough to exclude nanotechnology developed weapons that are prohibited by weapons treaties. However, the adequacy of the existing principles and rules of weapons law still needs to be reviewed in light of the specific characteristics of nanotechnology-enabled or -enhanced weapons or weapon systems and their transformative impact on the means and methods of warfare employed in the future battlespace.

III. WEAPONS LAW PARADOX

A frequent criticism is that law continues to lag behind technological advancement, treaties prohibiting or restricting specific technological developments tending to be reactive and defined restrictively with technical precision.⁴⁹ This is because the adoption of such treaties necessarily depends on multiple variables including—but by no means limited to—strategic considerations, military necessity, political interests and costs associated with weapons development, as well as a catalytic event that rapidly escalates public stigmatization of a particular weapons technology.⁵⁰ Negotiations for regulating specific technological developments pose particular challenges as it is difficult to fully appreciate the transformative impacts of weapons

47. CWC, *supra* note 22, art. II(9).

48. See Krutzsch & Trapp, *supra* note 46, at 75 (even with toxic side effects when such weapons are used).

49. Timothy L.H. McCormack, *A Non Liqueur on Nuclear Weapons—The ICJ Avoids the Application of General Principles of International Humanitarian Law*, 316 INTERNATIONAL REVIEW OF THE RED CROSS 76, 90 (1997).

50. Robert McLaughlin & Hitoshi Nasu, *Introduction: Conundrum of New Technologies in the Law of Armed Conflict*, in NEW TECHNOLOGIES AND THE LAW OF ARMED CONFLICT, *supra* note 5, at 1, 12–13. In recent years, civil society has increased its influence on the development of weapon treaties. See, e.g., Kenneth Anderson, *Ottawa Convention Banning Landmines, the Role of International Non-Governmental Organizations and the Idea of International Civil Society*, 11 EUROPEAN JOURNAL OF INTERNATIONAL LAW 91 (2000).

technology and the full implications of its regulation in the future battlespace.

As a result of balancing competing interests during diplomatic negotiations, drafting a weapons treaty tends to become arbitrary line-drawing and one that lacks coherent, principle-based reasoning.⁵¹ For example, explosive projectiles prohibited under the 1868 St. Petersburg Declaration were limited to those weighing under 400 grammes, a more or less arbitrary distinction, reflecting the dividing line discernible at that time between explosive artillery and rifle munitions, only the latter being considered dispensable in terms of their military utility.⁵²

An example of where technology has altered the manner in which weapons may be employed is that of flattening or expanding bullets, whose use against enemy forces during armed conflict is prohibited under the 1899 Hague Declaration Concerning Expanding Bullets.⁵³ These rounds have been radically refined with technological advancement, to the point that they have become a preferred munition for policing because they have better immediate stopping power than full-metal-jacketed rounds and tend to stay in the body of the target rather than passing through and creating risk to bystanders.⁵⁴ A similar situation may soon arise with regard to biological and chemical weapons, with nanotechnology enabling a targeted delivery of biochemical agents without a risk of uncontrolled dispersal. These weapons (as will be discussed further below in relation to incapacitating chemical agents) may become a preferred means of disabling the target in law enforcement operations, while their use during armed combat would remain prohibited.

51. See BOOTHBY, *supra* note 33, at 60.

52. Frits Kalshoven, *Arms, Armaments and International Law*, 191 RECUEIL DES COURS 185, 207–8 (1985-II). Later, light explosive or incendiary projectiles weighing less than 400 g were developed and have been widely accepted unless they are used against persons. *See id.* at 223.

53. Declaration (IV, 3) Concerning Expanding Bullets, *supra* note 19. Note, however, that the customary international law status of this prohibition is disputed. *See* OFFICE OF THE GENERAL COUNSEL, U.S. DEPARTMENT OF DEFENSE, LAW OF WAR MANUAL § 6.5.4.4 (2015) [hereinafter DOD LAW OF WAR MANUAL].

54. Kenneth Watkin, *Chemical Agents and “Expanding” Bullets: Limited Law Enforcement Exceptions and Unwarranted Handcuffs?*, in THE LAW OF WAR IN THE 21ST CENTURY, *supra* note 8, at 193, 199; Robert McLaughlin, *Unmanned Naval Vehicles and the Law of Naval Warfare*, in NEW TECHNOLOGIES AND THE LAW OF ARMED CONFLICT, *supra* note 5, at 229, 237.

To the extent that weapons treaties are considered to be a particular manifestation of the general principles of weapons law, such as the prohibition of superfluous injury or unnecessary suffering and the prohibition of indiscriminate weapons, technological advances, combined with the changing nature of hostilities, may create a disjuncture between the original rationale underpinning the weapons treaty and the general principles of weapons law. This may happen, for example, due to the increased military necessity of a particular weapon prohibited under the treaty (as is the case with flattening and expanding bullets) or the development of technology that enables a weapon prohibited as inherently indiscriminate to be more discriminately targetable (as is arguably the case with nanotechnology-enabled targeted delivery of biochemical agents). With further exploitation of the unique ability provided by nanotechnology to miniaturize weapons and weapons platforms, enhance accuracy and manipulability of precision attacks, and provide a greater range of focused force application, this disjuncture may loom larger, generating a “weapons law paradox.” This paradox leaves weapons that are intrinsically illegal under the general principles unregulated,⁵⁵ while weapons that are not considered as conflicting with the general principles are found to be regulated by a specific weapons treaty.

The dynamics that cause this paradox can be better understood when the weapons law principles are dissected into the constitutive elements—military necessity and humanity—that underpin many of the existing rules of the law of armed conflict, including those concerning weaponry.⁵⁶ These elements are not fixed, but are subject to change over the course of years and centuries as technology evolves and the nature of warfare changes. Thus, at the dawn of twentieth century the use of flattening and expanding rounds was viewed as causing unnecessary suffering, even in light of the military necessity of stopping advancing soldiers who continued to fight

55. For such arguments, see, e.g., EITAN BARAK, *DEADLY METAL RAIN: THE LEGALITY OF FLECHETTE WEAPONS IN INTERNATIONAL LAW* 179–202 (2011); Jason A. Beckett, *Interim Legality: A Mistaken Assumption?—An Analysis of Depleted Uranium Munitions under Contemporary International Humanitarian Law*, 3 *CHINESE JOURNAL OF INTERNATIONAL LAW* 43 (2004); Owen Thomas Gibbons, *Uses and Effects of Depleted Uranium Munitions: Towards a Moratorium on Use*, 7 *YEARBOOK OF INTERNATIONAL HUMANITARIAN LAW* 191, 206–24 (2004).

56. See especially Michael N. Schmitt, *Military Necessity and Humanity in International Humanitarian Law: Preserving the Delicate Balance*, 50 *VIRGINIA JOURNAL OF INTERNATIONAL LAW* 795 (2010).

after suffering an injury from a single completely jacketed rifle bullet.⁵⁷ Today military necessity arguably demands the use of such bullets, for example, in a counterterrorism operation in a densely populated area or on board a civilian aircraft to minimize the risk of collateral damage inflicted upon innocent bystanders.⁵⁸ A similar observation can be made when, for example nanotechnology contributes to the development of an anti-personnel explosive munition that is designed to explode inside the human body or detonate on impact with human tissue causing damage within only a defined parameter, which would significantly reduce the risk of civilian casualties in the vicinity of a lawful target, even in a densely populated area. It has been widely affirmed that the anti-personnel munition that is designed to explode within the human body or detonate on impact with the human tissue is prohibited as causing superfluous injury or unnecessary suffering under customary international law.⁵⁹ Could these changes of circumstances, including those facilitated by military applications of nanotechnology, disturb the equilibrium that underpinned the ban on these weapons as a clear manifestation of the superfluous injury or unnecessary suffering principle and render the St. Petersburg Declaration completely obsolete?

Before reaching any conclusion on this question, it must be acknowledged that the notion of humanity may also evolve as the technology affects the way in which wars can be fought and also, arguably, as the societal

57. See JAMES BROWN SCOTT, THE PROCEEDINGS OF THE HAGUE PEACE CONFERENCES: THE CONFERENCE OF 1899, at 276–78 (1920) (Remarks by General Sir John Ardagh). See also Frits Kalshoven, *The Soldier and His Golf Clubs*, in ETUDES ET ESSAYS SUR LE DROIT INTERNATIONAL HUMANITAIRE ET SUR LES PRINCIPES DE LA CROIX-ROUGE, EN L'HONNEUR DE JEAN PICTET 369, 374–76 (Christophe Swinarski ed., 1984).

58. Remarks reportedly made by Christopher Greenwood in his keynote address, “Legal Aspects of Current Regulations,” Third International Workshop on Wound Ballistics, Thun, Switzerland, March 28–29, 2001, cited in W. Hays Parks, *Conventional Weapons and Weapons Reviews*, 8 YEARBOOK OF INTERNATIONAL HUMANITARIAN LAW 55, 89–90 (2005). See also Steven Haines, *Weapons, Means and Methods of Warfare*, in PERSPECTIVES ON THE ICRC STUDY ON CUSTOMARY INTERNATIONAL HUMANITARIAN LAW 258, 272 (Elizabeth Wilmshurst & Susan Breau eds., 2005); George H. Aldrich, *Customary International Humanitarian Law—An Interpretation on Behalf of the International Committee of the Red Cross*, 76 BRITISH YEARBOOK OF INTERNATIONAL LAW 503, 520 (2006).

59. See especially HENCKAERTS & DOSWALD-BECK, *supra* note 15, r. 78; BOOTHBY, *supra* note 33, at 142–43. Cf. DOD LAW OF WAR MANUAL, *supra* note 53, § 6.5.4.3.

perception of acceptable human suffering changes.⁶⁰ The notion of humanity in the general context of the law of armed conflict is primarily—at least as it currently stands—understood by reference to the protection of civilians, as found in rules such as the prohibition of indiscriminate weapons, as well as in the related principles of discrimination, proportionality and the duty to exercise precautions in targeting (what I will refer to as the first thesis of humanity). This notion of humanity in warfare is not new. The 1863 Lieber Code reads:

As civilization has advanced during the last 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. The principle has been more and more acknowledged that the unarmed citizen is to be spared in person, property, and honor as much as the exigencies of war will admit.⁶¹

It is this meaning of humanity that is used as an underlying logic in the scenarios introduced above to drive a potential shifting of the balance, not against military necessity, but in reinforcing the military necessity of employing weapons that would otherwise be considered prohibited as causing superfluous injury or unnecessary suffering. What, then, is the element of humanity that is actually sacrificed in this trade-off?

Unlike the prohibition on indiscriminate weapons, which aims to protect civilians from attack, the superfluous injury or unnecessary suffering principle applies regardless of the legal status of the person upon which the injury or suffering is inflicted. Indeed, the notion of humanity in this sense is articulated in the St. Petersburg Declaration which states in its preamble that “the employment of arms which uselessly aggravate the sufferings of disabled man, or render their death inevitable . . . would, therefore, be contrary to the laws of humanity.”⁶² This principle, as reaffirmed by the International Court of Justice in its advisory opinion on the *Legality of the Use by a*

60. For the military ethics debate on this point, see, e.g., PAULINE M. KAURIN, *THE WARRIOR, MILITARY ETHICS AND CONTEMPORARY WARFARE: ACHILLES GOES ASYMMETRICAL* (2014).

61. U.S. Department of War, Instructions for the Government of Armies of the United States in the Field art. 22, General Orders No. 100, Apr. 24, 1863, *reprinted in* THE LAWS OF ARMED CONFLICTS 6 (Dietrich Schindler & Jiri Toman eds., 2004).

62. St. Petersburg Declaration, *supra* note 18.

State of Nuclear Weapons in Armed Conflict,⁶³ provides the cardinal legal protection (and a few particular manifestations of it under specific treaties) accorded to combatants and others who may be lawfully targeted in terms of the means of warfare that may be legitimately employed against them (what I will refer to as the second thesis of humanity). It is this second thesis of humanity that is sacrificed in the trade-off in the scenarios described above, i.e., the element of humanity which concerns the protection of combatants and other lawful targets from superfluous injury or unnecessary suffering and, arguably, inevitable death, rather than the first thesis of humanity, which provides that the “unarmed citizen is to be spared.” Although this second thesis of humanity is not to be sacrificed under the current understanding and application of the principle of humanity, this customary international law rule may undergo reformation if it can be shown that military necessity derives, for example, from an anti-personnel explosive munition designed to cause damage within only a defined parameter, and if State practice demonstrates over time that the superfluous injury or unnecessary suffering principle is not interpreted as prohibiting such a munition.⁶⁴

IV. THE POTENTIAL OF NANOTECHNOLOGY TO BRING CHANGE TO THE LAW OF WEAPONRY

At the advent of an era in which nanotechnology enables the development and enhancement of focused force application capabilities that can reduce the risk of civilian casualties, it is likely that tension will arise between the two theses of humanity, rather than between a single, fixed notion of humanity and military necessity. While achieving a greater level of precision and certainty of lethality against lawful targets could reduce civilian casualties and make warfare more “humane,” it may at the same time prompt us to revisit the second thesis of humanity—that limits the degree of injury or suffering that can be inflicted upon lawful targets—and re-examine its role in applying and developing the law of weaponry in the context of future warfare.

63. *Legality of Nuclear Weapons*, *supra* note 13, ¶¶ 77–78 (“[I]t is prohibited to cause unnecessary suffering to combatants: it is accordingly prohibited to use weapons causing them such harm or uselessly aggravating their suffering.”).

64. The author is particularly grateful to Dr. Boothby for his comments in the development of this argument.

With a focus on applications of nanotechnology that enable scientists to produce mechanically controllable precision munitions capable of limiting the impact of the attack to a defined parameter to reduce or completely eliminate the risk of civilian casualties, this Part considers how the second thesis of humanity may evolve with respect to restrictions on the degree of injury or suffering inflicted upon lawful targets. It does so by contextualizing this question in terms of two academic debates that have recently taken place on the power to kill or capture and the legality of incapacitating chemical agents.

A. The Power to Kill or Capture Debate

One of the recent debates where the second thesis of humanity may become of relevance is the argument, which appears in Part IX of the International Committee of the Red Cross's (ICRC) *Interpretive Guidance on the Notion of Direct Participation in Hostilities under International Humanitarian Law*,⁶⁵ that attempts to justify greater restrictions upon the means and methods of warfare employed against lawful targets. Most relevantly, the *Interpretive Guidance* suggests "considerations of humanity require that, within the parameters set by the specific provisions of IHL [international humanitarian law], no more death, injury, or destruction be caused than is actually necessary for the accomplishment of a legitimate military purpose in the prevailing circumstances."⁶⁶

Written in the context of direct participation in hostilities by civilians, this statement clearly aims to extend the superfluous injury or unnecessary suffering requirement beyond its original remit of weapons law into a broader legal context, while acknowledging that considerations of humanity play a role only within the parameters set by the specific provisions of the law of armed conflict. However, Nils Melzer, who was primarily responsible for the drafting of the *Interpretive Guidance*, appears to take the argument a step further without articulating the restrictive role of the considerations of humanity when he states that "the restrictive aspect of the principle of military necessity requires that there be no reasonable alternative while in-

65. INTERNATIONAL COMMITTEE OF THE RED CROSS, INTERPRETIVE GUIDANCE ON THE NOTION OF DIRECT PARTICIPATION IN HOSTILITIES UNDER INTERNATIONAL HUMANITARIAN LAW (2009) [hereinafter INTERPRETIVE GUIDANCE], available at <https://www.icrc.org/eng/assets/files/other/icrc-002-0990.pdf>.

66. *Id.* at 80.

terfering significantly less with humanitarian or other values, which IHL aims to protect from the effects of the hostilities.”⁶⁷

The problems and flaws in these arguments, extensively and convincingly discussed by Hays Parks,⁶⁸ need not be repeated here. However, one of the most relevant grounds of his critique for the purpose of the present discussion is succinctly expressed as follows:

Other than general or specific limitations on conventional weapons, such as those contained in the protocols to the 1980 Convention on Certain Conventional Weapons, nations otherwise have written law of war treaties to protect war victims while prudently declining to impose treaty restrictions on decisions by battlefield commanders or individual soldiers with respect to application of force against enemy combatants or civilians taking a direct part in hostilities. The ICRC’s effort to the contrary with reference to general principles such as *humanity*, *military necessity*, and *proportionality* is devoid of any reference to treaty provisions, or State practice, instead attempting an approach governments have assiduously avoided.⁶⁹

A more narrowly-defined and specific rule-based power to kill or capture debate has taken place between Ryan Goodman and Michael Schmitt.⁷⁰ Goodman’s central thesis focuses on the circumstances in which an individual is considered *hors de combat*, in particular, whether combatants who no longer have the means to defend themselves, but who are not injured, sick or surrendering, are indeed protected from direct attack as *hors de combat*.⁷¹ Yet, more relevant to the present discussion is his attempt to find a broader, theoretical support for his “least-restrictive-means” analysis in the superfluous injury or unnecessary suffering principle regulating the

67. NILS MELZER, TARGETED KILLING IN INTERNATIONAL LAW 293–94 (2008).

68. W. Hays Parks, *Part IX of the ICRC “Direct Participation in Hostilities” Study: No Mandate, No Expertise, and Legally Incorrect*, 42 NEW YORK UNIVERSITY JOURNAL OF INTERNATIONAL LAW AND POLITICS 769, 796–827 (2010).

69. *Id.* at 806 (emphasis in original) (footnotes omitted).

70. Ryan Goodman, *The Power to Kill or Capture Enemy Combatants*, 24 EUROPEAN JOURNAL OF INTERNATIONAL LAW 819 (2013); Michael N. Schmitt, *Wound, Capture, or Kill: A Reply to Ryan Goodman’s “The Power to Kill or Capture Enemy Combatants,”* 24 EUROPEAN JOURNAL OF INTERNATIONAL LAW 855 (2013); Ryan Goodman, *The Power to Kill or Capture Enemy Combatants: A Rejoinder to Michael N. Schmitt*, 24 EUROPEAN JOURNAL OF INTERNATIONAL LAW 863 (2013).

71. Goodman, *The Power to Kill or Capture Enemy Combatants*, *supra* note 70, at 830–36.

means and methods of warfare States can employ.⁷² Relying on this weapons law principle, Goodman develops the following analysis:

States do not, however, retain the prerogative to use the weapon when there is clearly no military benefit. It is in this sense that the prohibition on superfluous injury and unnecessary suffering operates. That is, either as a result of a general principle of necessity or as a more specific prohibition on *unnecessary* suffering. LOAC [law of armed conflict] forbids the use of methods and means of combat that are neither able nor intended to achieve a military benefit.⁷³

Assuming that by “a general principle of necessity”⁷⁴ he means military necessity, then reliance on it would invite the same criticism that has been made against the *Interpretive Guidance* by Parks. The notions of military necessity and humanity are both embedded in the specific rules of the law of armed conflict and do not exist as independent prescriptive norms that can be invoked to derogate from specific rules of the law of armed conflict or to restrain belligerents’ freedom of conduct.⁷⁵ As Schmitt remarks in his critique of Goodman’s thesis, “every IHL rule represents an attempt by States to craft a fair balance between the need to be effective in battle and the desire to humanize it. . . . [I]t is not in itself a separate prescriptive norm with independent valence.”⁷⁶

With regard to the second ground of Goodman’s argument, that a particular use of a weapon may be prohibited “as a more specific prohibition on *unnecessary* suffering,” the application of the superfluous injury or unnecessary suffering principle to methods of warfare should be approached with caution. While Article 35(2) of Additional Protocol I refers not only to weapons but also to methods of warfare, its application is subject to the same interpretive tests as those that apply to weapons; namely, whether, by reference either to the design intent or the effects of normal or expected

72. *Id.* at 836–37.

73. *Id.* at 837 (emphasis in original) (footnote omitted).

74. An alternative understanding is necessity as a circumstance precluding wrongfulness in the sense of State responsibility for a breach of obligations under the law of armed conflict; however, this does not make sense as “a general principle of necessity” is used to restrict the freedom of State action.

75. COMMENTARY ON THE ADDITIONAL PROTOCOLS OF 8 JUNE 1977 TO THE GENEVA CONVENTIONS OF 12 AUGUST 1949, ¶ 1389 (Yves Sandoz, Christophe Swinarski & Bruno Zimmerman eds., 1987).

76. Schmitt, *supra* note 70, at 857.

use, the method is of a nature to cause superfluous injury or unnecessary suffering,⁷⁷ and whether a balance exists between the degree of injury or suffering inflicted and the degree of military necessity underlying the choice of a particular method of warfare.⁷⁸ With the exception of specifically prohibited methods of warfare such as no quarter and starvation,⁷⁹ this balance cannot be generalized or clarified without an insight into the actual situation in which the method is employed.⁸⁰

A clear trend that emerges from this brief analysis of the power to kill or capture debate is that attempts are consistently made to find a legal basis for restricting the conduct of warfare under the notion of military necessity, giving little consideration to the humanitarian impact of technological advances in weaponry. By restricting the application of the debate to situations where armed forces operate against selected individuals under their control,⁸¹ the proponents of the power to capture side of the debate attempt to remove the first thesis of humanity from the equation. But in doing so, they fail to articulate the countervailing humanitarian factor to military necessity—the humanitarian considerations that render the use of a particular means or method of warfare unnecessary, when compared to the alternatives, to achieve the same military objective. Is it the circumstances in which the lawful target is deprived of his or her life, or is it the particular form of means or method of warfare—such as armed unmanned aerial vehicles (generally known as “drones”)—that allegedly renders a killing unnecessary or inhumane?

Assuming it is the circumstances in which the lawful target is deprived of his or her life which the proponents are concerned about, given the restricted scope of their argument, its internal logic starts to collapse as the circumstances change when an alternative method is employed. For exam-

77. See, e.g., 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, 470–71 (2006); Parks, *supra* note 68, at 76–82.

78. Government experts attending at the Conference on the Use of Certain Conventional Weapons in Lucerne in 1974 were in general agreement on this point. See INTERNATIONAL COMMITTEE OF THE RED CROSS, REPORT ON THE CONFERENCE OF GOVERNMENT EXPERTS ON THE USE OF CERTAIN CONVENTIONAL WEAPONS ¶¶ 23–24 (1975). See also COMMENTARY ON THE ADDITIONAL PROTOCOLS, *supra* note 75, ¶ 1428.

79. Additional Protocol I, *supra* note 13, arts. 40 and 54(1), respectively.

80. See Kalshoven, *supra* note 52, at 234–35; Greenwood, *supra* note 31, at 195–99. Note, however, their observations are made in relation to weapons.

81. INTERPRETIVE GUIDANCE, *supra* note 65, at 80–81; Goodman, *The Power to Kill or Capture Enemy Combatants*, *supra* note 70, at 826–28.

ple, the *Interpretive Guidance* refers to a situation where a lawful target is sitting in a restaurant located within an area firmly controlled by the opposing party, suggesting that this lawful target should be neutralized through capture or other non-lethal means.⁸² Drawing on this proposition, the UN Special Rapporteur on Extrajudicial, Summary or Arbitrary Executions also argues that “rather than using drone strikes, U.S. forces should, wherever and whenever possible, conduct arrests, or use less-than-lethal force to restrain.”⁸³ However, as soon as an alternative method is employed, for example, using a special forces unit to capture the person, he or she may move into an area heavily populated by civilians or may be surrounded by civilians by the time the unit arrives, resulting in civilian casualties that could have been avoided if the target had been engaged instantly using a “drone.” Therefore, the proposition that a less-than-lethal means or method should be employed under certain circumstances is inextricably linked with an assessment under the law of targeting in which the first thesis of humanity plays a central role.

Alternatively, the proponents of the power to capture argument may contend that it is the particular means and method of warfare adopted to neutralize a lawful target, for example, the specific manner in which an unmanned aerial vehicle is used to produce a lethal outcome, that is considered unnecessary or inhumane. The question then comes squarely within the scope of weapons law, inquiring whether there is any basis for concluding that the particular means and method of warfare employed is of an inhumane nature, such as of a nature to cause superfluous injury or unnecessary suffering, and whether it should be prohibited notwithstanding the fact that it is the most effective means and method to reduce or eliminate the risk of civilian casualties. As nanotechnology contributes to increases in the sophistication of the application of force (e.g., through miniaturization of unmanned aerial vehicles or self-guiding bullets) and reduces or completely eliminates the risk of civilian casualties, this will become a more relevant question, with a greater focus on the meaning and impact of the second thesis of humanity for weapons regulation. In this respect, the power to kill or capture debate can be better seen as one possible future legal approach to weapons law, heralding a new humanitarian law era in which

82. INTERPRETIVE GUIDANCE, *supra* note 65, at 81.

83. Special Rapporteur on Extrajudicial, Summary or Arbitrary Executions, *Study on Targeted Killings*, ¶ 77, U.N. Human Rights Council, U.N. Doc. A/HRC/14/24/Add.6 (May 28, 2010) (by Philip Alston), available at <http://www2.ohchr.org/english/bodies/hrcouncil/docs/14session/A.HRC.14.24.Add6.pdf>.

questions concerning “humane” ways to attack lawful targets may be more fully explored, rather than as an argument that reflects *lex lata*.

B. The Legality of Incapacitating Chemical Agents Debate

The tension between the first and second theses of humanity has also arisen with respect to the use of incapacitating chemical agents during armed conflict. As discussed in Part II, incapacitating agents—whether they are made from biological pathogens or have chemical properties—are prohibited from development, production, acquisition, stockpiling, retention or transfer, as well as use as weapons under any circumstances by the BWC and the CWC. The use of nanotechnology to produce novel biochemical agents does not create a legal loophole in the comprehensive treaty bans. The term “never under any circumstances” that commonly appears in the BWC and the CWC makes it clear that the use of biological and toxin weapons, as well as chemical weapons, is prohibited both in international and non-international armed conflict.⁸⁴ The prohibition is also considered to be customary international law.⁸⁵ However, the application of the rule to law enforcement is excluded explicitly under the CWC, and, arguably, under the BWC as one of “peaceful purposes.”⁸⁶ These exceptions to the prohibitions may have increasingly wider implications given the expansive nature of modern military operations, particularly in law enforcement-type situations and the lower end of intensity of non-international armed conflicts.⁸⁷

Indeed, a greater utility has recently been advocated for riot control agents (RCAs) as a method of undertaking counterterrorism operations,⁸⁸ and the United States has long maintained a policy of using RCAs in defensive military modes, in circumstances that can be interpreted as wider than domestic law enforcement purposes.⁸⁹ On October 26, 2002, Russian

84. See BOOTHBY, *supra* note 33, at 319, 321; DOD LAW OF WAR MANUAL, *supra* note 53, § 6.8.

85. HENCKAERTS & DOSWALD-BECK, *supra* note 15, at 256, 260.

86. See Michael Crowley, *The Use of Incapacitants in Law Enforcement*, in WEAPONS UNDER INTERNATIONAL HUMAN RIGHTS LAW 357, 379–80 (Stuart Casey-Maslen ed., 2014).

87. See Watkin, *supra* note 54, at 196–97.

88. J.P. Perry Robinson, *Difficulties Facing the Chemical Weapons Convention*, 84 INTERNATIONAL AFFAIRS 223, 228–29 (2008).

89. BOOTHBY, *supra* note 33, at 135; David Turns, *Weapons in the ICRC Study on Customary International Humanitarian Law*, 11 JOURNAL OF CONFLICT & SECURITY LAW 201, 224 (2006).

Spetsnaz Forces deployed a chemical agent—the powerful, fast-acting opiate Fentanyl—in a Moscow theater through its ventilation system in order to liberate 634 hostages taken by Chechen separatists.⁹⁰ This occurred arguably in the wider context of a non-international armed conflict between Russian forces and Chechen separatists.⁹¹ More recently, concerns have been raised about the increased interest among States in the use of incapacitating chemical agents in situations where law enforcement operations evolve into a non-international armed conflict, or where the State denies the existence of an armed conflict. The practice, it is feared, would result in a potentially dangerous erosion of the comprehensive ban on chemical weapons.⁹²

RCAs such as CS gas and pepper spray have been the chemical agents traditionally used for law enforcement purposes. The CWC defines RCAs as “[a]ny chemicals not listed in a Schedule, which can produce rapidly in humans sensory irritation or disabling physical effects which disappear within a short time following termination of exposure.”⁹³ There is an unresolved debate as to whether law enforcement purposes within the meaning of the CWC are confined to the use of RCAs or could extend to the use of incapacitating chemical agents more broadly.⁹⁴ Other chemical substances—including novel toxic chemicals produced by applications of nanotechnology, for example, to enhance temporary physical disabling effects or

90. Judith Miller & William J. Broad, *Hostage Drama in Moscow: The Toxic Agent; U.S. Suspects Opiate in Gas in Russia Raid*, NEW YORK TIMES, Oct. 29, 2002, at A1, available at <http://www.nytimes.com/2002/10/29/world/hostage-drama-in-moscow-the-toxic-agent-us-suspects-opiate-in-gas-in-russia-raid.html>.

91. For details, see, e.g., David P. Fidler, *The Meaning of Moscow: “Non-Lethal” Weapons and International Law in the 21st Century*, 859 INTERNATIONAL REVIEW OF THE RED CROSS 525 (2005).

92. See Press Release, International Committee of the Red Cross, ICRC Calls on States to Prevent the Development of Toxic Chemicals as Weapons (Feb. 6, 2013), available at <https://www.icrc.org/eng/resources/documents/news-release/2013/02-06-toxic-chemicals-weapons.htm>; WEAPONS OF MASS DESTRUCTION COMMISSION, WEAPONS OF TERROR: FREEING THE WORLD OF NUCLEAR, BIOLOGICAL AND CHEMICAL ARMS 132 (June 1, 2006), available at http://www.ycsg.yale.edu/assets/downloads/weapons_of_terror.pdf.

93. CWC, *supra* note 22, art. II(7).

94. See Krutzsch & Trapp, *supra* note 46, at 94–101; Crowley, *supra* note 86, at 375–78; Mirko Sossai, *Drugs as Weapons: Disarmament Treaties Facing the Advances in Biochemistry and Non-Lethal Weapons Technology*, 15 JOURNAL OF CONFLICT & SECURITY LAW 5, 21–22 (2010); Julian Perry Robinson, *The Negotiations on the Chemical Weapons Convention: A Historical Overview*, in THE NEW CHEMICAL WEAPONS CONVENTION: IMPLEMENTATION AND PROSPECTS 17, 31 (Michael Bothe, Natalino Ronzitti & Allan Rosas eds., 1998).

to tailor the nature or severity of the incapacitating effects to a particular objective desired by the user⁹⁵—and their precursors could theoretically be considered lawful if developed or used for law enforcement purposes, but not if those substances are used as a means of warfare, or their types or quantities produced are not consistent with their use for law enforcement purposes.⁹⁶ Yet, the fundamental distinction between means of warfare and law enforcement should inform the design purpose if a new chemical agent is to be developed for law enforcement purposes alone. Thus, if lethality or permanent harm is the primary characteristic of a novel nano-chemical agent, the presumption is that such a substance cannot be considered as being developed or produced for law enforcement purposes.⁹⁷

The central issue for the purpose of the present analysis lies with nanotechnology-enhanced incapacitating chemical agents that are not designed, primarily at least, to be lethal or to cause permanent harm, being used for hostile purposes in armed conflict. Even though clearly prohibited under the CWC, if one attempts to extend the power to kill or capture debate further, it would make sense to allow the military to use such weapons in order to disable lawful targets until it becomes practicable to detain them.⁹⁸ This would be particularly so when those nanotechnology-enhanced incapacitating chemical agents can be delivered on lawful targets only, for example, by using miniaturized unmanned aerial vehicles to inject chemical agents via physical contact with the target, shooting directly at the target from close range, or by controlling the physical and time parameters in which the incapacitating effects of nanotechnology-enhanced chemicals may last.

95. For recent developments on chemical and biological weapons that are not considered to be weapons of mass destruction, see Robinson, *supra* note 88, at 237–38.

96. CWC, *supra* note 22, art. II(1)(a).

97. A more challenging question arises when lethality or permanent harm remains a potential consequence of using a novel nano-chemical agent primarily designed for a temporary incapacitation. This question is of general relevance to so-called “non-lethal weapons,” which have been criticized for their potential lethality notwithstanding the fact that police are routinely issued with firearms in some countries, which are designed to kill or cause permanent harm. *See generally* DAVID A. KOPLOW, NON-LETHAL WEAPONS: THE LAW AND POLICY OF REVOLUTIONARY TECHNOLOGIES FOR THE MILITARY AND LAW ENFORCEMENT (2006).

98. Concerns may still be raised that incapacitating chemical agents could be used as a prelude to the application of lethal force against those identified as targets. However, those who are incapacitated as a result would be considered *hors de combat*.

The foundational rationale underpinning the comprehensive ban on chemical weapons, as it appears in the preamble to the CWC, is the “prohibition and elimination of all types of weapons of mass destruction,” indicating the shared understanding that chemical weapons are indiscriminate in nature.⁹⁹ Indeed, a report prepared by the UN Secretary-General as the basis for possible political and legal action by States with respect to chemical and bacteriological (biological) weapons expressed concern that technological advances would allow them to cause casualties on a large scale and that their effects were unpredictable.¹⁰⁰ This rationale resonates with the first thesis of humanity, placing the indiscriminate risk to civilians as the central consideration of humanity. If this was the only concern that led the States to comprehensively ban chemical weapons under any circumstances, there seems to be no legally sound reason to maintain the comprehensive ban against the sophistication of delivery methods enabling precision strikes of incapacitating chemical agents enhanced by nanotechnology on lawful targets.¹⁰¹

This observation can be further contextualized when the comprehensive ban on chemical weapons is compared with the historical development of the ban on asphyxiating or deleterious gases. The idea to prohibit the employment of projectiles whose sole purpose is to spread asphyxiating or deleterious gases was opened for discussion during the 1899 Hague Conference. Disagreement, although expressed only by the U.S. delegate,

99. A similar rationale is offered on the prohibition of poison as a weapon in the *Commentary* on Additional Protocol I, which observes that “poison is unlawful in itself, as would be any weapon which would, by its very nature, be so imprecise that it would inevitably cause indiscriminate damage.” COMMENTARY ON THE ADDITIONAL PROTOCOLS, *supra* note 75, ¶1402.

100. U.N. Secretary-General, Chemical and Bacteriological (Biological) Weapons and the Effects of Their Possible Use 1–3, U.N. Doc. A/7575/Rev.1–S/9292/Rev.1 (1969) (“The fear today is that the scientific and technological advances of the past few decades have increased the potential of chemical and bacteriological (biological) weapons to such an extent that one can conceive of their use causing casualties on a scale greater than one would associate with conventional warfare. . . . [T]he outstanding characteristics of this class of weapons, particularly bacteriological (biological) weapons, is the variability, amounting, under some circumstances to unpredictability, of their effects.”).

101. It should be remembered, however, that, as explained earlier, weapons are not always prohibited on rational, legally sound grounds. One may recall that the U.S. proposal to exempt anti-personnel landmines equipped with self-destruction or self-deactivation features has been rejected in favor of a comprehensive ban. *See, e.g.*, Michael Dolan & Chris Hunt, *Negotiating in the Ottawa Process: The New Multilateralism*, 5(3) CANADIAN FOREIGN POLICY JOURNAL 25, 41–45 (1998).

stemmed from the basic question as to whether “it is no more cruel to asphyxiate one’s enemies by means of deleterious gases than with water, that is to say, by drowning them, as happens when a vessel is sunk by the torpedo of a torpedo-boat.”¹⁰² Captain Schéine, the Russian delegate, rejected this comparison by pointing out that:

Many persons may be saved even if they have been wounded or placed out of action, in case a vessel is sunk by a torpedo. Asphyxiating gases, on the contrary, would exterminate the whole crew.

This procedure would therefore be contrary to the humane idea which ought to guide us, namely, that of finding means of putting enemies out of action without putting them out of the world.¹⁰³

This debate ended with the almost unanimous adoption of the 1899 Hague Declaration prohibiting the use of projectiles whose sole purpose was to spread asphyxiating or deleterious gases (only the United States objected),¹⁰⁴ a rule which was subsequently reaffirmed in Article 23(e) of the 1907 Hague Regulations.¹⁰⁵ Jean Pascal Zanders observes that asphyxiating or deleterious gases were seen at that time as a novel weapon and the product of scientific advance, whose barbarous, treacherous and cruel nature was similar to poison, which had been condemned universally as an ancient and barbaric form of warfare.¹⁰⁶ Likewise, Frits Kalshoven observes that “the overriding argument in favour of a ban on use was their barbaric and unnecessarily cruel, that is, inhumane character.”¹⁰⁷ It is thus clear that the primary rationale for the prohibition of asphyxiating or deleterious gases concerned the second thesis of humanity according protection to those who might lawfully be targeted from certain forms of killing.

As explained above, the central concern of the parties to the CWC was the impact of chemical weapons on civilian lives, rather than with the protection of combatants from death caused by chemical reaction, as evi-

102. Third meeting of The Hague First Commission, June 22, 1899, in SCOTT, *supra* note 57, at 283 (Remarks of Captain Alfred T. Mahan).

103. *Id.*

104. Declaration (IV, 2) on the Use of Projectiles the Object of Which is the Diffusion of Asphyxiating or Deleterious Gases, *supra* note 20.

105. Hague Regulations, *supra* note 13.

106. Jean Pascal Zanders, *International Norms against Chemical and Biological Warfare: An Ambiguous Legacy*, 8 JOURNAL OF CONFLICT & SECURITY LAW 391, 406 (2003).

107. Kalshoven, *supra* note 52, at 216.

denced by the Convention provisions addressing chemicals that can cause temporary incapacitation or permanent harm to humans or animals, as well as those that can cause death. However, as applications of nanotechnology enable precise delivery of incapacitating chemical agents at specific lawful targets or greater control of the incapacitating effects of chemical agents, the dilemma, which might well have already been recognized, will start to become clearer. That is, that it is prohibited to use nanotechnology-enhanced incapacitating chemical agents delivered by a precision device, also enhanced by applications of nanotechnology, while it is not prohibited to achieve the same military outcome by using the same device to deliver an explosive munition and detonate in close proximity to (e.g., just above the head of) the lawful target.¹⁰⁸

Suppose that in both instances the risk of civilian casualties is completely eliminated. Whether a consensus will then emerge among States for an introduction of a new law or a change to the existing law that focuses more on the second thesis of humanity would depend upon their balancing of the military necessity-humanity equation with respect to the manner in which lawful targets can be attacked. How will States interpret the balance between military necessity and humanity if nanotechnology enables the development of incapacitating chemical agents that can be applied with great assurance and precision on chosen lawful targets? Will States insist on maintaining the integrity of existing treaty prohibitions on biochemical weapons, thus precluding the acquisition of potentially more humane options than currently exist? These are the questions that will confront States and the public conscience as nanotechnology contributes to the sophistication of the application of force that eliminates (or at least greatly reduces) the risk of civilian casualties.

V. CONCLUSION

As is the case with any new technology, it is expected that nanotechnology will change the way in which wars can be fought. For example, nanotechnology will enable existing weapons to be more discriminate by allowing mechanical precision and manipulation of attacks, as well as more focused application of force. The existing weapons law principles and rules are both broad enough to address development of weapons enabled or enhanced by

108. Assuming that detonating the explosive inside the human body or upon impact with the human tissue is considered to violate the superfluous injury or unnecessary suffering principle.

applications of nanotechnology, and specific enough to exclude them if prohibited under the existing weapons treaties. However, as this article has discussed, the exploitation of the unique ability provided by nanotechnology is likely to produce more cases caught by the “weapons law paradox,” the situation that leaves intrinsically illegal weapons under the general principles unregulated, while weapons that do not conflict with the general principles are found to be regulated by a specific weapons treaty.

The examination of two recent debates concerning the degree of injury or harm inflicted upon lawful targets, namely, the power to kill or capture and the legality of incapacitating chemical agents, has revealed that the role of the second thesis of humanity as a countervailing factor to military necessity has not been duly taken into account beyond its manifestation in the superfluous injury or unnecessary suffering principle. As nanotechnology contributes to the sophistication in application of force that eliminates (or at least greatly reduces) the risk of civilian casualties, it is expected that the focus of the debate will shift from what is an acceptable risk to civilian lives to what is an acceptable form of disabling lawful targets. The extent to which the second thesis of humanity may play a role in shifting the focus of this debate for the development of weapons law hinges upon how States and the public conscience react to the emergence and widespread deployment of nanotechnology-enabled or -enhanced weapons in the battlespace; whether they are merely content with reduction of civilian casualties during military operations or whether they shift their attention to the questions concerning “humane” ways to disable lawful targets.

As the history of weapons law development evidences, however, humanitarian concern is not the only motivation for States to negotiate and conclude a treaty to prohibit or restrict the use of a particular weapon. As Boothby observes,

In the treaty law dealing with weaponry there are frequent examples of treaties negotiated to address weapons seen at the time as excessively injurious or as injuring an adversary in a way that pricked the international conscience. It tends to be the combined effect of the development made in the relevant weapons technology and the degree, or perhaps lack, of effective defences against those new developments, which constitute the threat that, in turn, prompts the negotiation of a legal instrument. Sometimes it is the humanitarian concern aroused by the nature and/or extent of the anticipated injury or death that is the primary motive here; some-

times it is the recognition by certain states that the technology that others possess poses a potentially unanswerable threat.¹⁰⁹

At the time of writing, technological advances in weaponry are heavily concentrated in the traditional weapons manufacturing States such as the United States and Russia. Yet, nanotechnology is a transformative technology that is being acquired and developed at an alarming pace even in countries that have traditionally been considered technologically under-developed, such as India, Iran and Thailand.¹¹⁰ While one may expect that the pre-existing technological capabilities would provide an advantage for technologically developed countries in the arms race involving nanotechnology, well-developed weapons manufacturing infrastructures, procurement processes and integrated weapons systems based on conventional technologies do not easily allow them to undertake the major restructure or overhaul of existing military infrastructures necessary to take advantage of nanotechnological innovation. It remains to be seen whether this will lead to a nanotechnological arms race; whether it is considered to pose a potentially unanswerable threat; and then what will be the effect on the debate concerning the meaning of humanity when people are facing the ultimate precision strikes.

109. BOOTHBY, *supra* note 33, at 121–22.

110. See DIRECTOR, DEFENSE RESEARCH & ENGINEERING, *supra* note 2, at 30–33.