National Defence Défense nationale

Canadian Forces College

Collège des Forces Canadiennes

# KILLER ROBOTS: EMPLOYING LETHAL AUTONOMOUS ROBOTS WITHIN *JUS IN BELLO* AND THE REQUIREMENT FOR COMMAND RESPONSIBILITY

Lieutenant-Commander P.D. Smithers

## JCSP 38

## Master of Defence Studies

**Disclaimer**



## PCEMI 38

## Maîtrise en études de la défense

**Avertissement**



Canada

CANADIAN FORCES COLLEGE – COLLÈGE DES FORCES CANADIENNES
JCSP 38 – PCEMI 38
2011 – 2012

MASTER OF DEFENCE STUDIES – MAÎTRISE EN ÉTUDES DE LA DÉFENSE

# KILLER ROBOTS: EMPLOYING LETHAL AUTONOMOUS ROBOTS WITHIN *JUS IN BELLO* AND THE REQUIREMENT FOR COMMAND RESPONSIBILITY

By Lieutenant-Commander P.D. Smithers

## ABSTRACT

Robotic systems have become commonplace in military operations in recent years, receiving frequent media exposure. Consequently, military plans to develop lethal autonomous robots (LARs) have created considerable debate among governments, international organizations, non-governmental organizations and other interested parties about the potential use of these *killer robots* in combat. This paper briefly examines the historical background behind robotic weapons, distinguishes LARs from other robots and weapons, and then discusses the impact of popular culture on the public's perception of them. It explores LAR's potential impact on just war theory's *jus in bello* principles of discrimination, proportionality and military necessity, as well as the legal requirement for command responsibility. Examples of relevant modern military doctrine and contemporary accidents and mishaps involving military robotics are presented. Arguments for and against LARs are considered, and the foregoing discussion is applied to develop courses of action to mitigate problems posed by lethal autonomous robot employment. A warning zone or battlespace management model is described for low-risk situations, while a *human on the loop* model incorporating operator override is provided for more complex scenarios. The paper concludes that lethal robots should not be autonomous, but should have a human on the loop in a supervisory or veto capacity, until such time as they may be reliably operated within the *jus in bello* principles of just war theory and the legal requirement for command responsibility.

# TABLE OF CONTENTS

# CHAPTER ONE

# KILLER ROBOTS – AN INTRODUCTION

*The robotics revolution has been described as the next major revolution in military affairs, on par with the introduction of gunpowder and nuclear bombs.*

– Christof Heyns, U.N. Special Rapporteur on Extrajudicial, Summary or Arbitrary Executions, U.N. report A/HRC/23/47, 9 April, 2013, paraphrasing P.W. Singer, *Wired for War: The Robotic Revolution and Conflict in the 21st Century*, 2009.

Yesterday's popular science fiction may not necessarily be today's science fact, but it may conjure disturbing images of dystopian futures and militarized technology gone wrong. Technology has been exploited by states throughout the ages to prepare for or fight wars, contributing to various revolutions in military affairs (RMAs).[1] One modern military technological development which has received considerable contemporary scrutiny is military forces' use of robotic systems in combat.

If a *robot* is broadly defined as "a machine capable of carrying out a complex series of actions automatically,"[2] then *robotic systems* may be said to include a wide range of modern military equipment that operates with varying degrees of independence from human supervision.[3] Modern naval examples of robotic systems within the range of

[1] A discussion of revolutions in military affairs is found in Williamson Murray and MacGregor Knox, "Thinking about revolutions in warfare," in *The Dynamics of Military Revolution, 1300 – 2050*, ed. MacGregor Knox and Williamson Murray (Cambridge: Cambridge University Press, 2001), Kindle edition, locations 109–175, 292–361.

[2] Katherine Barber *et al.*, *Oxford Canadian Dictionary of Current English*, 722.

[3] See Human Rights Watch and Harvard Law School International Human Rights Clinic, "Losing Humanity: The Case Against Killer Robots," November, 2012, http://www.hrw.org/sites/default/files/reports/arms1112ForUpload_0_0.pdf, 2, for a description of human interaction with robotic systems. Examples of modern military robotics applications are found in Patrick Lin, "Introduction," chap. 1 in *Robot Ethics: The Ethical and Social Implications of Robotics,* ed. Patrick Lin, Keith Abney and George A. Bekey (Cambridge: MIT Press, 2012), 4–5.

that definition include any number of above-water fire control systems, smart sea mines like the American CAPTOR mine, weapon mounts such as the Mk 15 Phalanx Close-In Weapon System (CIWS), and combat management systems like the American Aegis and Canadian SHINPADS systems.[4]

The field of robotics also includes a subset of autonomous or semi-autonomous unmanned vehicles, commonly called *drones*.[5] The robotic capabilities of one representative aerial drone, the Northrop Grumman RQ-4 Global Hawk, are described by its manufacturer as follows:

> Once mission parameters are programmed into Global Hawk, the air vehicle can autonomously taxi, take off, fly, remain on station capturing imagery, return, and land. Ground-based operators monitor the system's health and status, and can re-task the air system's navigation and sensor plans during flight as necessary.[6]

---

[4] The examples are described in Federation of American Scientists, "MK 60 Encapsulated Torpedo (CAPTOR)," last modified 13 December, 1998, http://www fas.org/man/dod-101/sys/dumb/mk60.htm; US Navy Fact File, "Mk 15 – Phalanx Close-In Weapons System (CIWS)," last updated 15 November, 2013, http://www.navy.mil/navydata/fact_display.asp?cid=2100&tid=487&ct=2; David Ewing *et al.*, *IHS Jane's C4ISR & Mission Systems 2013–2014: Maritime* 2nd ed. (Coulsdon: IHS Jane's, 2013), 110–111; and Norman Friedman, *The Naval Institute Guide to World Naval Weapons Systems*, 5th ed. (Annapolis: Naval Institute Press, 2006), 59–60.

[5] Barber *et al.*, *Oxford Canadian Dictionary of Current English*, 242; and, Paul J. Springer, *Military Robots and Drones: A Reference Handbook* (Santa Barbara: ABC-Clio, 2013), 2-5. Chapter 3 of this paper will discuss the definition of robot in more detail. While examples and discussion points in this paper may refer to drones, they should be taken to refer to the larger field of military robots in general, unless otherwise stated.

[6] Northop Grumman, Facts, "RQ-4 Global Hawk High-Altitude, Long-Endurance Unmanned Aerial Reconnaissance System," last modified May, 2008. http://www.northropgrumman.com/Capabilities/RQ4Block10GlobalHawk/Documents/HALE_Factsheet.pdf, 1.

Naval drones, generally referred to as maritime unmanned systems, comprise a considerably smaller and lesser-known segment of contemporary military robotics.[7] The Royal Canadian Navy (RCN) primarily operates maritime unmanned systems in surface target practice as well as underwater/seabed intervention roles.[8]

Military forces have been interested in robotics to varying degrees—and with mixed results—since World War One, and Global Hawk's progenitor was a radio-controlled hobby plane purchased for use as a military target drone in 1940.[9] However, it is only in recent years that robots such as MQ-1 Predator and MQ-9 Reaper drones have become seemingly ubiquitous in the battlefield. In his book, *Wired for War: the Robotics Revolution and Conflict in the 21st Century*, P.W. Singer describes United States (U.S.) drone usage during its invasion of Iraq as involving over five thousand drones of twenty-two different types, outnumbering the American military manned aircraft inventory by almost two to one in numbers of airframes.[10] The International Federation of Robotics, an international organization that promotes the robotics industry, estimated that approximately sixty-two hundred military robots were sold worldwide in 2012.[11] Singer

---

[7] North Atlantic Treaty Organization, Combined Joint Operations from the Sea Centre of Excellence, *Guidance for developing Maritime Unmanned Systems (MUS) capability* (Norfolk: NATO, 9 July 2012), http://cjoscoe.org/docs/MUS_Final_9July2012.pdf, 1.

[8] J. Greenlaw, "Sea mines and naval mine countermeasures: are autonomous underwater vehicles the answer, and is the Royal Canadian Navy ready for the new paradigm?" (Masters of Defence Studies paper, Canadian Forces College, 2013), 73, 84–85.

[9] P.W. Singer, *Wired for War: The Robotics Revolution and Conflict in the 21st Century* (New York: Penguin Press, 2009), 46–49.

[10] *Ibid.*, 32, 37.

[11] International Federation of Robotics, "Executive Summary – World Robotics 2013," http://www.ifr.org/uploads/media/Executive_Summary_WR_2013.pdf, 18.

contends "an RMA driven by robotics is at hand."[12] If, as MacGregor Knox and Williamson Murray state, "[m]ilitary organizations embark upon an RMA by devising new ways of destroying their opponents,"[13] then the above statistics suggest a robotic drone RMA is already here.

The use of armed drones in combat is not new. During Word War One, the Germans employed explosive-laden FL-7 wire-guided—later, radio-controlled—boats as coastal defences. In 1917, one of these boats was credited with damaging the British monitor HMS EREBUS.[14]

The pervasiveness of robotics is by no means a phenomenon unique to militaries. In 2002, iRobot's Roomba robotic vacuum cleaners began cleaning private homes;[15] today, iRobot offers eight different domestic robots, including models that mop floors, clean pools, and sweep out eaves troughs.[16] In his introduction to *Robot Ethics: the Ethical and Social Implications of Robotics*, Patrick Lin states "[r]obots have been employed in manufacturing for decades, particularly in auto factories, but they are also used in warehouses, movie sets, electronics manufacturing, food production, printing,

---

[12] Singer, *Wired for War* …, 204.

[13] Murray and Knox, "Thinking about revolutions in warfare," in *The Dynamics of Military Revolution* …, locations 302–303.

[14] Singer, P.W. "Drones Don't Die - A History of Military Robotics," last modified May 5, 2011, http://www.historynet.com/drones-dont-die-a-history-of-military-robotics htm.

[15] Singer, *Wired for War* …, 22.

[16] See iRobot's web site at iRobot, "Your Home, Our Robots," last accessed July 18, 2014, http://www.irobot.com/us/learn/home.aspx.

fabrication, and many other industries."[17] The International Federation of Robotics estimated a worldwide population of over 1.2 million industrial robots at the end of 2012, with over 2.4 million sold since they were first introduced in the late 1960s; it also estimated sales of 22 million robots for personal use between 2013 and 2016.[18] Humanity appears to be running closer to Bill Gates' vision of "a robot in every home."[19]

Ironically, the 2004 motion picture *I, Robot* is set in a fictitious future where there seems to be a service robot in every home and the major robot manufacturer plans to produce "one robot for every five humans."[20] Elements of popular culture such as motion pictures play a role in the march of technology. This is clearly the case in weapons technology, and the *public perception* of weapons technology, when the influence of dystopian science fiction literature, television and motion pictures is considered. Science fiction stories are character tales where technology is a stressor, and military-themed science fiction in particular can tell tales of the societal impact of RMAs based on fantastic technology.[21] The fictitious nature of popular culture influences notwithstanding, it may not be difficult to imagine lethal autonomous robots (LARs) in

---

[17] Lin, *Robot Ethics…, 5.*

[18] International Federation of Robotics, "Executive Summary …," 13, 17, 9.

[19] See generally Bill Gates, "A Robot in Every Home," *Scientific American* 296, no. 1 (January 2007): 58–65, http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=23362665&site=ehost-live.

[20] Jeff Vintar and Akiva Goldsman, "Susan Calvin's Tour of USR," *I, Robot*, DVD, directed by Alex Proyas (Beverly Hills: Twentieth Century Fox Home Entertainment: 2004).

[21] Harry Turtledove, "Introduction," in *The Best Military Science Fiction of the 20th Century*, ed. Harry Turtledove and Martin H. Greenberg (Random House Publishing Group, 2001), Kindle edition, locations 45–66.

action after watching the movie *The Terminator*,[22] when one considers that writers of military science fiction foretold the invention of tanks and military use of aircraft before World War One.[23]

Today, modern computer technology may be said to have begun closing the gap with science fiction, as the prospect of LARs comes closer to reality due to advances in computer hardware and software technology.[24] Militaries, academics and other interested parties foresee a day when robotic weapons systems will not only function remotely at great distances from their operators, but also have such autonomy of action that they will be capable of employing lethal force without human control.[25] This could eventually lead

---

[22] James Cameron, Gale Anne Hurd and William Wisher Jr, *The Terminator*, DVD, directed by James Cameron (1984; Santa Monica: MGM Home Entertainment, 2006).

[23] Turtledove, "Introduction," in *The Best Military Science Fiction* …, locations 59–65.

[24] S.Y. Harmon and D.W. Gage, "Current technical research issues of autonomous robots employed in combat," in *Proceedings of EASCON 1984:17th Annual Electronics and Aerospace Conference* (Washington D.C.: Institute of Electrical and Electronics Engineers, 11–13 September 1984): 215–219. http://www.public navy mil/spawar/Pacific/Robotics/Documents/Publications/1984/eascon84.pdf, 215; and, Ronald C. Arkin, "The Case for Ethical Autonomy in Unmanned Systems," *Journal of Military Ethics* 9, No. 4 (2010): 332–341, http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=56042210&site=ehost-live: 332–334.

[25] See, *inter alia*, Arkin, "The Case for Ethical Autonomy …," 332; Noel Sharkey, "The evitability of autonomous robot warfare," *International Review of the Red Cross* 94, no. 886 (Summer 2012): 787–799, http://www.icrc.org/eng/assets/files/review/2012/irrc-886-sharkey.pdf: 788; Springer, *Military Robots and Drones* …, 27–28; Jeffrey S. Thurnher, "No one at the controls: Legal implications of fully autonomous targeting," *Joint Force Quarterly* 67 (4th Quarter, October 2012): 77–84, http://www.dtic mil/doctrine/jfq/jfq-67.pdf, 78; United States, Office of the Secretary of Defense, "Unmanned Aircraft Systems Roadmap: 2005 – 2030," Washington: Department of Defense, August 4, 2005, http://www.fas.org/irp/program/collect/uav_roadmap2005.pdf, A-5, D-9, J-2; and, UK MoD Joint Doctrine Note 2/11, *The UK Approach to Unmanned Aircraft Systems* (Shrivenham: Development, Concepts and Doctrine Centre, 30 March 2011), https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/33711/20110505JDN_211_UAS_v2U.pdf; 5-10–5-12.

to another revolution in military affairs, one in which one or more belligerents in a military conflict will commit no troops to a battle, sending LARs to fight in their stead.[26]

The potential use of LARs in combat is a multi-faceted issue that includes consideration of the current limits and anticipated march of technology, basic tenets of just war theory and the laws of armed conflict, popular culture's influence, the basic desire to protect human life, and other factors. This has contributed to increased interest in LARs on the part of state governments, international organizations, non-governmental organizations such as Human Rights Watch (HRW) and the International Committee of the Red Cross (ICRC), and lesser-known special interest groups such as the International Committee for Robot Arms Control.[27] Some non-governmental organizations have banded together to launch a campaign opposing LARs.[28] Interest in LARs has become pervasive enough to prompt the presentation of two special reports on the danger of LARs to the United Nations (U.N.) General Assembly in the last four years.[29]

---

[26] Sharkey, "The evitability …," 788.

[27] Representative reports by states and agencies include UK MoD Joint Doctrine Note 2/11; General Assembly, A/65/321, *Interim report of the Special Rapporteur on extrajudicial, summary or arbitrary executions*, August 23, 2010, http://daccess-dds-ny.un.org/doc/UNDOC/GEN/N10/492/39/PDF/N1049239.pdf?OpenElement; Human Rights Watch, "UN: Start International Talks on 'Killer Robots,'" 13 November, 2013, http://www.hrw.org/news/2013/11/13/un-start-international-talks-killer-robots; International Committee of the Red Cross, "Autonomous weapons: States must address major humanitarian, ethical challenges," last updated 11 July, 2014, http://www.icrc.org/eng/resources/documents/faq/q-and-a-autonomous-weapons htm; and, International Committee for Robot Arms Control, "Home," last accessed 14 June, 2014, http://icrac.net/.

[28] Campaign to Stop Killer Robots, "About Us," last accessed 14 June, 2014, http://www.stopkillerrobots.org/about-us/.

[29] General Assembly, A/65/321; and, General Assembly, A/HRC/23/47, *Report of the Special Rapporteur on extrajudicial, summary or arbitrary executions, Christof Heyns*, 9 April, 2013, http://www.ohchr.org/Documents/HRBodies/HRCouncil/RegularSession/Session23/A-HRC-23-47_en.pdf, respectively.

This paper will draw upon a variety of academic, military, governmental and non-governmental sources to examine certain aspects of the phenomenon of LARs. It will explore the background behind these *killer robots*, develop an understanding of what they are—and are not—with reference to the impact of popular culture, and examine their use within the principles of just war theory and the Laws of Armed Conflict. Using examples drawn from contemporary incidents involving military robotics and existing naval warfare doctrine, it will be argued that lethal robots should not be autonomous, but instead should have a *human on the loop* in a supervisory or veto capacity, to comply with just war theory's *jus in bello* principles of discrimination, proportionality and military necessity, as well as the legal requirement for command responsibility.

# CHAPTER TWO

## THE ROBOTS ARE COMING!

> *Some military and robotics experts have predicted that fully autonomous weapons could be developed within 20 to 30 years. Such weapons, also known as "killer robots," would be able to select and engage targets without human intervention.*
> – Human Rights Watch and Harvard Law School International Human Rights Clinic, "Losing Humanity: the Case against Killer Robots," 2012.

Military robotics development may be traced back to World War One, as discussed earlier. During World War Two, Russia employed armed radio-controlled tanks during its 1939 – 1940 invasion of Finland;[30] another example is Germany's Goliath remotely-controlled demolition vehicle which—although said to have had little impact in combat—is credited with inspiring future robotics development.[31] The German Army employed Goliaths in demolitions, landmine clearance and anti-tank roles.[32]

Postwar advances in computer technology, spurred by wartime interest in code-breaking, decreased the size of computers while increasing their computing power as transistors replaced vacuum tubes and integrated circuits debuted in 1958.[33] In 1965, Gordon Moore stated what became known as Moore's Law, "that the number of

[30] Eric Sofge, "Tale of the Teletank: The Brief Rise and Long Fall of Russia's Military Robots," *Popular Science*, 7 March, 2014, http://www.popsci.com/blog-network/zero-moment/tale-teletank-brief-rise-and-long-fall-russia%E2%80%99s-military-robots.

[31] Military History Monthly, "Back to the Drawing Board – The Goliath Tracked Mine," last modified July 12, 2012, http://www.military-history.org/articles/back-to-the-drawing-board htm.

[32] Steven M. Shaker and Alan R. Wise, *War without Men: Robots on the Future Battlefield* (MacLean, VA: Pergamon-Brassey's, 1988), 16–17.

[33] Springer, *Military Robots and Drones*…, 12–14.

transistors on a chip will double approximately every two years."[34] Bill Gates notes that the tremendous increases in computer processing power and storage capacity since the 1970s has aided modern robot development.[35]

Examining more modern military robotics, the U.S. tested TALON SWORDS, an armed unmanned ground vehicle, in Iraq. It could be armed with a variety of man-portable weapons and was credited with remarkable accuracy, able to hit a target over a mile away.[36] The Samsung Techwin SGR-1A Intelligent Surveillance and Security Guard Robot was designed as a replacement for South Korean soldiers guarding the Korean De-Militarized Zone. It can recognize, track and fire upon human targets under manual control or autonomously.[37] In the air defence realm, Israel's Iron Dome system boasts the ability to detect and destroy incoming rocket, artillery and missile fire at short to medium ranges under semi-automatic control, with an intercept rate as high as ninety percent.[38] The system conducts a threat assessment of incoming fire based on a variety of

---

[34] Intel, "Moore's Law Inspires Intel Innovation," last accessed 15 April, 2014, http://www.intel.com/content/www/us/en/silicon-innovations/moores-law-technology.html.

[35] Gates, "A Robot in Every Home."

[36] See Lorie Jewell, "Armed Robots to March into Battle," *United States Department of Defense - Transformation*, 6 December, 2004, http://www.defense.gov/transformation/articles/2004-12/ta120604c.html.

[37] Eric Sofge, "Top 5 Bomb-Packing, Gun-Toting War Bots the U.S. Doesn't Have," *Popular Mechanics*, 1 October, 2009, http://www.popularmechanics.com/technology/military/4249209; and Jean Kumagai, "A Robotic Sentry For Korea's Demilitarized Zone," *IEEE Spectrum*, 1 March, 2007, http://spectrum.ieee.org/robotics/military-robots/a-robotic-sentry-for-koreas-demilitarized-zone.

[38] Haroon Husain, "Iron Dome counter - rocket, artillery and missile (C-RAM) system," *Defence Journal* 16 no. 9 (April 2013): 52–56, http://search.ebscohost.com/login.aspx?direct=true&db=tsh&AN=87618529&site=ehost-live, 52–54.

factors, before assigning a missile to the threat and requesting a human operator's permission to fire.[39]

The Predator and Reaper drones mentioned above were introduced in 1994 and 2007 respectively, and have been deployed in both Afghanistan and Iraq.[40] They are equipped with robust sensor suites and satellite links, and armed with missiles; Reapers may also carry laser-guided bombs.[41] In July 2013, 237 Predators and 112 Reapers were in service with the U.S. military.[42] Today, the U.S. and United Kingdom are developing autonomous stealthy armed drone technology with their respective X-47B and Taranis unmanned combat aerial vehicle technology demonstration experiments.[43]

In the naval domain, the U.S. contracted Radio Corporation of America (RCA) to develop what became the Aegis weapon system in 1969, in response to earlier studies into area air defence for warships in multi-threat scenarios. After successful prototype tests five years later, the system went to sea as the primary combat system of the United States Navy's new Ticonderoga Class cruisers in 1983. The Aegis system boasts an

---

[39] *Ibid.*, 53; and "Iron Dome Battle Management Demonstrated," *Defense Update*, last accessed 4 July, 2014, http://defense-update.com/photos/iron_dome_bms html.

[40] "Attack of the Drones," *Current Events* 109 no. 21 (29 March 2010): 4–5, http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=49091125&site=ehost-live.

[41] *Ibid*. Originally unarmed reconnaissance UAVs, Predators were modified to fire missiles beginning in 2002, as discussed in United States Air Force, "MQ-1B Predator," last modified 20 July, 2010, http://www.af mil/AboutUs/FactSheets/Display/tabid/224/Article/104469/mq-1b-predator.aspx.

[42] See Figure 3 in Department of Defense, 14-S-0553, *Unmanned Systems Integrated Roadmap FY 2013-2038*, n.d., http://www.defense.gov/pubs/DOD-USRM-2013.pdf, 5.

[43] See Northrop Grumman, Capabilities, "X-47B UCAS," last accessed 20 March, 2014, http://www.northropgrumman.com/Capabilities/X47BUCAS/Pages/default.aspx; and, BAE Systems, "Taranis," last accessed 20 March, 2014, http://www.baesystems.com/enhancedarticle/BAES_157659/taranis?_afrLoop=168568191008000.

ability to execute the entire *detect-to-engage sequence*—that is, to detect, locate, track, classify and identify a target, then select the appropriate weapon and fire it upon the target—for multiple supersonic air targets at a variety of ranges simultaneously, with or without operator intervention.[44] The system is becoming prolific among western navies: according to its current manufacturer, "[t]he navies of Australia, Japan, Norway, Republic of Korea, Spain and the U.S. currently use or plan to use the Aegis system developed by Lockheed Martin on more than 100 ships."[45]

The RCN has developed its own robotic command and control systems. Development of the Shipboard Integrated Processing and Display System (SHINPADS) began in 1974. The system combined multi-sensor data fusion, threat evaluation and weapons assignment software, tactical data link interfaces and display subsystems with a distributed computer architecture. This system was fit to the RCN's Halifax and Iroquois Class ships.[46] SHINPADS has three modes of operation: manual, where operators control all aspects of weapon employment; semi-automatic, where the command and control system assigns weapons to threats but the operator fires the weapons; and automatic—typically used against very fast targets—where the command and control

[44] The division of RCA that produced Aegis later became part of Lockheed Martin. A detailed description of Aegis weapon system development and capabilities is found in Ewing *et al.*, *IHS Jane's C4ISR* …, 108–111. The detect-to-engage sequence is described in Federation of American Scientists, "Naval Weapons Systems," chap. 1 in *Fundamentals of Naval Weapons Systems*, last accessed 18 March 2014, http://www.fas.org/man/dod-101/navy/docs/fun/part01.htm.

[45] Lockheed Martin, "Where in the World is Aegis," last accessed 20 March, 2014, http://www.lockheedmartin.ca/us/products/aegis/where-in-the-world-is-aegis.html.

[46] Ewing *et al.*, *IHS Jane's C4ISR* …, 6-8.

system executes the entire detect-to-engage sequence but the operator has the ability to veto target engagement.[47]

Many navies have stand-alone robotic weapons systems. The ubiquitous Mk 15 *Phalanx* CIWS, a robotic point defence weapon system capable of independently executing the detect-to-engage sequence against fast-moving air and surface targets, first went to sea in 1980 and is currently fit to warships of twenty-five navies.[48]

Media reports and other sources provide examples of robotic systems employed in combat beyond the examples discussed earlier. During the Yom Kippur War, Israel employed unarmed Chukar target drones in diversionary feints against Arab missile batteries.[49] Israel also employed Scout reconnaissance drones for targeting during the First Lebanon War, later equipping them for communications jamming and electronic warfare.[50] On the ground, American forces used an unarmed robot to scout caves during cave-clearing operations in Afghanistan in 2002.[51]

---

[47] Friedman, *The Naval Institute Guide …*, 55, 59.

[48] Phalanx also has a manual mode, and may be integrated into a ship's combat management system. See US Navy Fact File, "Mk 15 – Phalanx …;" and Raytheon, "Phalanx Close-In Weapons System (CIWS)," last accessed 20 March, 2014, http://www.raytheon.com/capabilities/products/phalanx/.

[49] Ed Darack, "A Brief History of Unmanned Aircraft," *Air & Space/Smithsonian Magazine*, 17 May, 2011, http://www.airspacemag.com/photos/a-brief-history-of-unmanned-aircraft-174072843/?page=8.

[50] Israeli Air Force, "Israel Aircraft Industries 'Scout,'" last accessed 10 July, 2014, http://www.iaf.org.il/215-en/IAF.aspx; and Pierre Klochendler, "Drone Technology Takes Off," *Interpress News Agency*, 29 March, 2012, http://www.ipsnews.net/2012/03/drone-technology-takes-off/.

[51] Bootie Cosgrove-Mather, Associated Press, "Robots draw rough duty," *CBS News*, July 30, 2002, http://www.cbsnews.com/news/robots-draw-rough-duty/.

In the present day, media reports abound on accidents related to drone strikes in or near Afghanistan. However, there appear to be few examples of naval robotic systems in combat available from open sources. Perhaps the best-known but unfortunately tragic such example is USS VINCENNES' accidental downing of Iran Air flight 665 near the close of the Iran-Iraq War, which will be discussed later in this paper.[52]

Given the scrutiny which military robotic systems receive in the media not only today but since the 1998 Iran Air incident, why do militaries pursue development of robotics, and lethal autonomous robotics in particular? The common reason is that militaries want to relieve their personnel of "the three Ds: dirty, dangerous and dull [work]."[53] The United States Department of Defence lends a military context to that popular robotics phrase by stating:

> The attributes that make the use of unmanned preferable to manned aircraft in the above three roles are, in the case of the dull, the better sustained alertness of machines over that of humans and, for the dirty and the dangerous, the lower political and human cost if the mission is lost, and greater probability that the mission will be successful. Lower downside risk and higher confidence in mission success are two strong motivators for continued expansion of unmanned aircraft systems.[54]

Similar arguments may be applied to land-based or naval robotic systems. The rapid reaction time necessary to fight in modern combat is also a factor, as discussed in

[52] George C. Wilson, "Navy Missile Downs Iranian Jetliner," *Washington Post*, Monday, July 4, 1988, http://www.washingtonpost.com/wp-srv/inatl/longterm/flight801/stories/july88crash.htm.

[53] LeilaTakayama, Wendy Ju, and Clifford Nass, "Beyond Dirty, Dangerous, and Dull: What Everyday People Think Robots Should Do," paper presented at the 3rd ACM/IEEE Conference on Human-Robot Interaction, 2008, 15 March, 2008, http://chime.stanford.edu/wp-content/uploads/2012/09/beyond-dirty-dangerous-and-dull.pdf, 25.

[54] Secretary of Defense, "Unmanned Aircraft Systems Roadmap: 2005 – 2030," 2.

the naval robotic system descriptions above. The speed of weapon deployment has increased exponentially over the past century, and the corresponding reaction time necessary to defend against hostile weapons has similarly decreased to the point where a human's ability to react to a hostile threat can be insufficient.[55]

A perceived political or social attractiveness of military robotics may be another reason to pursue it. Phil Patton of *Wired Magazine* saw a post-First Gulf War public intolerance for casualties in the U.S. as a motivator for military robotics development.[56] This phenomenon is not unique to Americans: the same intolerance may be said to exist in Canada today, after the Canadian Armed Forces withdrawal from Afghanistan.[57] Frank Sauer and Niklas Schőrnig echo this sentiment by stating that killer drones cater to an electorate's aversion for casualties while also providing a solution that is cheaper and—at least theoretically—more accurate than soldiers; the lure of cheaper military forces is clear, and greater accuracy should help a state avoid breaching the Laws of Armed Conflict (LOAC).[58]

Perhaps the simplest reason for developing lethal autonomous robots can be summarized by Ronald C. Arkin's sentiment "[i]f your robotics research is of significance and it is published openly, it will be put to use in military systems by

---

[55] David R. Frieden, ed., *Principles of Naval Weapons Systems* (Annapolis: Naval Institute Press, 1985), 563–564, particularly Figures 20-1 and 20-2.

[56] Phil Patton, "Robots with the Right Stuff," *Wired* 4.03, March 1996, last accessed 19 July, 2014, http://archive.wired.com/wired/archive/4.03/robots html?pg=5&topic.

[57] Sean Maloney, "'Was It Worth It?' Canadian Intervention in Afghanistan and Perceptions of Success and Failure," *Canadian Military Journal* 14, no. 1, (Winter 2014), 21.

[58] Sauer, Frank and Niklas Schőrnig. "Killer drones: The 'silver bullet' of democratic warfare?" *Security Dialogue* 43(4) (2012): 363-380, www.sdi.sagepub.com/content/43/4/463: 369–370.

someone, somewhere, someday."[59] So militaries may feel pressure to either get out in front of the technology, or be left behind when their potential adversaries adopt it. The arms race such reasoning implies may already be happening in some theatres, when one considers the proliferation of drones into the hands of long-time Israeli enemies such as Iran, as discussed above; or terrorist organizations such as Hezbollah, which has launched drone attacks against Israel, and Hamas, which is also reported to have drone capability.[60]

The proliferation of military robots, frequent media stories about their use, and plans by western militaries to develop lethal autonomous robots have created considerable interest in military robots in general and development of LARs in particular. The U.S. Department of Defense's *Unmanned Aircraft Systems Roadmap: 2005 – 2030* implies that LARs could be employed in strike, air defense suppression or electronic attack roles; and the United Kingdom Ministry of Defence has produced a Joint Doctrine Note which includes operational vignettes and a brief discussion of the advantages and disadvantages of using LARs.[61] Major non-governmental organizations have responded with extensive position papers such as HRW and the Harvard Law School's *Losing Humanity: The Case Against Killer Robots*, which addresses the impact of LARs on international humanitarian law (IHL); and the ICRC has produced a massive issue of its

---

[59] Ronald C. Arkin, *Governing Lethal Behavior in Autonomous Robots* (Boca Raton: CRC Press, 2009), xvii.

[60] David Eshel, "Israel Intercept Two Attack UAV Launched by Hezbollah," *Defence Update*, 14 August, 2006, http://defense-update.com/2006/08/israel-intercept-two-attack-uav html; and, "Hamas, Hizbullah said to have fleet of drones on Israel border," *Geo-Strategy Direct*, 29 September, 2010: 6, http://search.ebscohost.com/login.aspx?direct=true&db=tsh&AN=55118967&site=ehost-live.

[61] Secretary of Defense, "Unmanned Aircraft Systems Roadmap: 2005 - 2030," A-4–A-5, A-7; and UK MoD Joint Doctrine Note 2/11, 5-10–5-12, 7-1–7-2. While a more recent U.S. roadmap will be discussed later in this paper, the 2005 roadmap serves to illustrate an official assessment of missions tat might be undertaken by LARs.

*International Review* entitled "New Technologies and Warfare," which discusses the legal and ethical implications of robotics, with considerable attention to LARs.[62]

Non-governmental interest in LARs does not stop there. Numerous non-governmental organizations of varying sizes, some with broad mandates and others with narrower special interests, banded together in April 2013, to form the pointedly-named *Campaign to Stop Killer Robots*. The International Committee for Robot Arms Control discussed earlier is one of the campaign's fifty members from twenty-three states. The campaign demonstrates a groundswell of non-governmental opposition to lethal autonomous robots across a broad range of professions, disciplines and interests.[63]

Finally, the ethical and legal debate about LARs speaks to two main themes of just war theory, a theory concerned with "the problems of justifying and restraining the violence of war."[64] In his book *Morality and Contemporary Warfare*, James Turner Johnson describes those themes in clear and concise terms:

> Looked at as a whole, just war tradition has two major thematic branches, classically denoted by the terms *jus ad bellum* and *jus in bello*. These have to do, respectively, with when it is just to resort to military force and what

---

[62] Human Rights Watch and Harvard Law School International Human Rights Clinic, "Losing Humanity …," is fifty-five pages in length. Articles including discussion of autonomous weapons account for approximately two fifths of the 428-page International Committee of the Red Cross, *International Review of the Red Cross* 94, No. 886 (Summer 2012), http://www.icrc.org/eng/resources/international-review/review-886-new-technologies-warfare/review-886-all.pdf.

[63] Campaign to Stop Killer Robots, "Who we are," last accessed 14 June, 2014. http://www.stopkillerrobots.org/coalition/.

[64] James Turner Johnson, *Can Modern War Be Just?* (New Haven: Yale University Press, 1984), 11.

it is justified to do in the use of force.[65]

A third theme outside the scope of this paper, *just post bellum*, is concerned with peace treaties, postwar reparations and rehabilitation.[66]

Just war theory attempts to provide moral guidance in statecraft related to war, the exercise of command by military commanders, and the actions of individuals.[67] It informs the U.N. Charter and the LOAC—also known as international humanitarian law and the Laws of War[68]—and intersects with the rules of engagement of military forces.[69] Arkin contends that:

> … it is the roboticist's duty to ensure they [LARs] are as safe as possible to both combatant and noncombatant alike, as is prescribed by our society's commitment to International Conventions encoded in the Laws of War and other similar doctrine—for example, the Code of Conduct and Rules of Engagement.[70]

In her book *Ethics: the Fundamentals*, Julia Driver states that normative ethics concerns "what we *ought* to do, or what we *ought* to be like."[71] If Arkin's statement

---

[65] James Turner Johnson, *Morality and Contemporary Warfare* (New Haven: Yale University Press, 1999), 27. Emphasis Johnson's.

[66] Brian Orend, *The Morality of War*, 2nd ed. (Peterborough: Broadview Press, 2013), Adobe Digital Edition, 20–21, 185–187.

[67] Johnson, *Morality* …, 25–26.

[68] Micheal Byers, *War Law: Understanding International Law and Armed Conflict* (Vancouver: Douglas & McIntyre, 2005), 115.

[69] Geoffrey S. Corn *et al.*, *The Law of Armed Conflict: An Operational Approach* (New York: Wolters Kluwer Law & Business, 2012), 125, 127.

[70] Arkin, *Governing Lethal Behavior*…, 5.

[71] Driver, Julia. *Ethics: the Fundamentals* (Malden, MA: Blackwell, 2006), Kindle edition, location 180. Emphasis Driver's.

above is extended to the ethical dimension of the debate over LARs, then the duty he describes could be said to also apply to militaries, governments and other concerned stakeholders as well.

# CHAPTER THREE

## A LAR BY ANY OTHER NAME …

*What is a robot? Ask a bunch of robotics experts, and you will get a bunch of answers.*
– Carnegie Science Center Roboworld homepage.

Any discussion of a technological topic as potentially complex as lethal autonomous robots might benefit from a precise definition of the topic itself. The etymology of the word *robot* comes from a play written in 1921 by Czech playwright Karel Čapek entitled *R.U.R. (Rossum's Universal Robots)*, whose eponymous subjects are manufactured humanoids sold for use as inexpensive labour.[72] Subsequently, as stated by Lisa Nocks in *The Robot: The Life Story of a Technology*:

> It [the word *robot*] ... became popular among science fiction writers as a way to describe the intelligent automatic machines that were appearing more frequently in their stories. By the 1960s, engineers began to apply the term "robot" to reprogrammable industrial machines that could do a variety of repetitive tasks independent of an operator.[73]

In modern times, exactly what constitutes a robot is a matter of some debate.[74] Following the above industrial meme, the Carnegie Science Centre provides a simple definition of robot which describes a reprogrammable tool-holding device with three or

---

[72] See generally Karel Čapek, *R.U.R. (Rossum's Universal Robots)*, trans. David Wyllie, University of Adelaide Library eBook, last updated 7 March, 2014, http://ebooks.adelaide.edu.au/c/capek/karel/rur/index.html. The robots' purpose is discussed in the introductory scene.

[73] Lisa Nocks, *The Robot: The Life Story of a Technology* (Westport: Greenwood Press, 2007), 3.

[74] George A. Bekey, "Current Trends in Robotics," chap. 2 in *Robot Ethics* …, 17.

more moving joints;[75] however, it then describes how a modern automobile might also be considered a robot due to its extensive computerization and automation.[76] Another simple and restrictive definition, used within the Canadian government, is "[a]n instrumented mechanism used in science or industry to take the place of a human being."[77] However, that definition excludes military applications. Leading roboticist George Bekey uses this definition:

> … a machine that senses, thinks, and acts. Thus, a robot must have sensors, processing ability that emulates some aspects of cognition, and actuators. Sensors are needed to obtain information from the environment. Reactive behaviors (like the stretch reflex in humans) do not require any deep cognitive ability, but on-board intelligence is necessary if the robot is to perform significant tasks autonomously, and actuation is needed to enable the robot to exert forces upon the environment. Generally, these forces will result in motion of the entire robot or one of its elements (such as an arm, a leg, or a wheel).[78]

This highly technical definition rules out devices operated completely by remote control such as the Goliath demolition vehicle mentioned earlier, as well as virtual devices.[79] It may be applied to naval combat management systems if a ship's weapons are considered to be actuators, since firing a naval weapon—whether it involves motion in aiming and firing a gun, or little more than electrically-fired thrust in launching a

---

[75] Carnegie Science Center, Roboworld, "What is a Robot?" Last accessed 14 March, 2014, http://www.carnegiesciencecenter.org/exhibits/roboworld-what-is-robot/.

[76] *Ibid*.

[77] *The New Encyclopaedia Britannica*, 1980 ed., s.v. "Robot," quoted in Public Works and Government Services Canada, "Termium Plus search results," last accessed 15 April, 2014, http://www.btb.termiumplus.gc.ca/tpv2alpha/alpha-eng.html?lang=eng&i=1&index=alt&__index=alt&srchtxt=ROBOT.

[78] George A. Bekey, *Autonomous Robots: From Biological Inspiration to Implementation and Control* (Cambridge: MIT Press, 2005), Kindle edition, locations 134–138.

[79] Bekey, "Current Trends in Robotics …," 18.

missile from a stationary canister mount—can be considered to be acting against a threat environment.

Robots that have some form of remote control, such as modern unmanned aerial vehicles (UAVs), are generally called *telerobots* by roboticists.[80] The FL-7 boats, Goliath demolition robots, TALON SWORDS, Predator and naval target drones discussed earlier may therefore be described as telerobots.

Robotic weapon systems with *automatic* modes of operation, such as an automatic rifle, are "self-loading and able to fire continuously,"[81] subject to the limitations of a weapon's ammunition supply. In contrast, *autonomous* is defined as "having self-government,"[82] implying that an autonomous device is able to choose and execute its own actions. Bekey states that "[a]utonomy refers to systems capable of operating in the real-world environment without any form of external control for extended periods of time."[83] This would exclude telerobots—most modern drones—from the class of autonomous robots.

The debate over robotics jargon extends to discussions of autonomy. Within the robotics community, some professionals consider autonomy in a narrow context of movement and navigation only, such as the autonomous flight control of the Global

---

[80] *Ibid.*, 18.

[81] Barber *et al.*, *Oxford Canadian Dictionary* …, 45.

[82] *Ibid.*, 46.

[83] Bekey, *Autonomous Robots* …, location 123.

Hawk discussed earlier.[84] Others define autonomy more broadly, discussing a robot's decision-making ability as an autonomous moral agent across a broad range of applications including health care, domestic service in homes, and military service.[85]

Besides suggesting a lack of agreed-upon jargon in the field of robotics,[86] neither of these interpretations appears to suit the military's intent for autonomous robot development, exemplified by the U.S. government's lexicon for autonomy in unmanned systems being forty-seven pages long.[87] Curiously, ambiguity or disagreement in robotics jargon may be said to extend to the American military, since there are no references to robots or autonomous systems in their official Department of Defence dictionary.[88] This paper will discuss autonomy within the context of armed robotic systems independently selecting and acting against targets.

There can be little doubt of the appropriately stark definition of the word *lethal*: an adjective meaning "causing or sufficient to cause death."[89] It is conceivable that lethal

---

[84] For example, MIT offers an online course focused on robot movement and navigation, based on Roland Siegwart, Iliah R. Nourbakhsh and Davide Scaramuzza, *Introduction to autonomous mobile robots,* 2nd ed. (Cambridge: MIT Press, 2011), at edX, "Autonomous Mobile Robots," last accessed 15 April, 2014, https://www.edx.org/course/ethx/ethx-amrx-autonomous-mobile-robots-1342.

[85] Colin Allen and Wendell Wallach, "Moral Machines: Contradiction in Terms or Abdication of Human Responsibility," chap. 4 in *Robot Ethics* …, 55–57.

[86] See note 74.

[87] NIST Special Publication 100-I-2.0, *Autonomy levels for Unmanned Systems (ALFUS) Framework – Volume I: Terminology*, ed. Hui-Min Huang (October 2008), http://www.nist.gov/el/isd/ks/upload/NISTSP_1011-I-2-0.pdf.

[88] Department of Defence, JP 1-02, *Department of Defense Dictionary of Military and Associated Terms* (Washington: Joint Chiefs of Staff, 15 June 2014), http://www.dtic.mil/doctrine/new_pubs/jp1_02.pdf.

[89] Barber *et al.*, *Oxford Canadian Dictionary*…, 470.

harm may be inflicted by an unarmed robot either accidentally or by design: consider, as hypothetical examples, an unmanned ground vehicle running over and fatally injuring an enemy soldier in the field—intentionally or not—or an unarmed drone being used as a missile as a last resort tactic. However, this paper focuses on armed robots deliberately programmed with lethal intent, following U.N. Special Rapporteur on Extrajudicial, Summary or Arbitrary Executions Christof Heyns' assumption that "unless specifically programmed to do so, robots would not cause intentional suffering on civilian populations."[90] The potential lethality of armed robots so programmed clearly separates them from their domestic or military unarmed counterparts.

What, then, would a lethal autonomous robot be? In a United States Army-funded survey designed to gauge the acceptability of robots in combat, Moshkina and Arkin described autonomy as the situation where "the robot itself is in control over its decisions, including those regarding the use of lethal force."[91] In his later book *Governing Lethal Behaviour in Autonomous Robots*, Arkin expanded that definition to allow for operational-level tasking or re-tasking of a robot, as follows:

> **Autonomous Robot**: A robot that does not require direct human involvement, except for high-level mission tasking; such a robot can make its own decisions consistent with its mission without requiring direct human authorization, including decisions regarding the use of force.[92]

---

[90] General Assembly, A/HRC/23/47, 10.

[91] Lilia Moshkina and Ronald C. Arkin, "Lethality and Autonomous Systems: Survey Design and Results," Georgia Tech GVU Center Technical Report GIT-GVU-07-16, 2008, http://www.cc.gatech.edu/ai/robot-lab/online-publications/MoshkinaArkinTechReport2008.pdf, 2.

[92] Arkin, *Governing Lethal Behavior*…, 51. Emphasis Arkin's.

The U.S. National Institute of Standards and Technology, which supplies the American government lexicon discussed above, neither provides a definition for lethal autonomous robots nor discusses armed unmanned systems. It does provide a definition of *unmanned system* which eliminates unpowered devices and provides for mobile or stationary systems, and in general terms it describes *full autonomy* as an ability to complete a defined mission in a changing external environment.[93]

A plainly-worded definition proposed by Major D.A. Goldsmith in a paper for the Canadian Forces College is “a self-governing mechanical apparatus, having actual fighting as a function that is capable of deliberately choosing to take a human life.”[94] While Goldsmith’s definition does not limit itself to vehicular robots, it may be too restrictive because it presumes that robotic systems are mechanical in nature, whereas robotic systems such as Aegis, SHINPADS or Iron Dome are primarily electronic.

The ICRC focuses more on effects, saying “lethal autonomous robots … would search for, identify and attack targets, including human beings, using lethal force without any human operator intervening.”[95] Perhaps the most important distinction between LARs and other robots, including drones, is summed up by the U.N. Office of the High Commissioner for Human Rights which states:

> Lethal autonomous robots (LARs), once they have been activated, can operate without further human intervention. While drones are operated by

[93] NIST Special Publication 100-I-2.0, 22, 28.

[94] D.A. Goldsmith, “Robots in the Battlespace: Moral and Ethical Considerations in the Use of Autonomous Mechanical Combatants” (Joint Command and Staff Course New Horizons paper, Canadian Forces College, 2008), 6.

[95] International Committee of the Red Cross, “Autonomous weapons ….”

> humans, these new weapons systems, not currently deployed, can make decisions about targets on their own.[96]

It is also important to consider what is *not* a lethal autonomous robot. Telerobots were eliminated above, due to their remote operation. Not all robotic weapons systems that remain should be considered robots, despite their ability to locate, track, guide themselves to and destroy a target after activation or launch. According to Paul J. Springer,

> There are some weapons systems that incorporate limited autonomy but that should not be considered robots or drones, even though they may include some robotic elements. While robots and drones are often considered expendable, in that their loss is not so costly as their corresponding manned platforms would be, they are not inherently designed to be single-use weapons.[97]

More plainly, a missile or torpedo fulfills its intended purpose by detonating to destroy its target, whereas a robot is intended to be re-used from one dull, dirty or dangerous mission to the next. Therefore, guided weapons such as active homing missiles, passive or active homing torpedoes, CAPTOR sea mines, cruise missiles, etc …, should not be considered robots, since they are only used once. In the RCN, guided weapons are considered to be rounds of ammunition vice autonomous weapons systems, due to their explosive content.[98]

---

[96] Office of the High Commission for Human Rights, "A Call for a moratorium on the development and use of lethal autonomous robots," last modified 31 May, 2013, http://www.ohchr.org/EN/NewsEvents/Pages/Acallforamoratoriumonthedevelopmentrobots.aspx.

[97] Springer, *Military Robots and Drones*…, 4.

[98] Department of National Defence, DAOD 3002-0, "Ammunition and Explosives," last updated 10 November, 2006, http://www forces.gc.ca/en/about-policies-standards-defence-admin-orders-directives-3000/3002-0.page.

Fully autonomous robots are not in service yet.[99] However, various modern lethal robotic systems cited in discussions about lethal autonomous robots have user-selectable modes of operation that fit the Office of the High Commissioner's definition above when the systems are placed in automatic mode. Representative systems with such selectable autonomy include the CIWS, Aegis and SGR-1A systems discussed earlier. These systems are typically employed only in semi-automatic or manual modes, or they have personnel monitoring their performance with the ability to inhibit the use of lethal force.[100] As stated by Springer, "[s]ome weapons, such as naval close-in-weapons systems (CIWS), have a limited degree of autonomy over firing decisions but are in operation only under combat conditions of little ambiguity."[101] The lack of a perceived air threat in the Persian Gulf in 1987 led USS STARK to leave its CIWS in manual mode to avoid accidental engagements of friendly or indigenous aircraft.[102]

The above discussion over the nature of robots in general and lethal autonomous robots in particular is by no means all-inclusive. However, it illustrates that the debate over lethal autonomous robots may be influenced as much by lexical semantics as it is by other factors, even within informed military and robotics communities.

---

[99] See note 96.

[100] See Harold Lee Wise, *Inside the Danger Zone: The U.S. Military in the Persian Gulf, 1987-1988* (Annapolis: Naval Institute Press, 2013), Kindle edition, location 594; Ewing *et al.*, *IHS Jane's C4ISR* …, 110; Sofge, "Top 5 Bomb-Packing, Gun-Toting War Bots …;" and Friedman, *The Naval Institute Guide* …, 55.

[101] Springer, *Military Robots and Drones*…, 53–54.

[102] Wise, *Inside the Danger Zone*…, locations 594–601.

Common threads in the various definitions for LARs presented above include independence from an operator and ability to execute the detect-to-engage sequence against targets—including people—with deadly force. The definition is broadened through inclusion of non-vehicular devices, and narrowed by exclusion of telerobots and guided weapons. Therefore, for the purposes of this paper, a lethal autonomous robot will be a reusable device which, once initiated, is capable of independently executing the detect-to-engage sequence with lethal effect.

# CHAPTER FOUR

## YOU SAY ROBOT, I SAY TERMINATOR

> *Recent advances in robotics have narrowed the line between science fiction and technological fact.*
>
> – Lisa Nocks*, The Robot: The Life Story of a Technology*.

> *In popular culture, films continue to dramatize and demonize robots, such as Metropolis, Star Wars, Blade Runner, Terminator, AI, and I, Robot, to name just a few.*
>
> – Patrick Lin*, Robot Ethics*: *The Ethical and Social Implications of Robotics*.

The previous chapter described how the word *robot* originated in a 1921 science fiction play. Almost a century later, popular culture has embraced technology through countless science fiction books, plays, television shows, motion pictures and internet webisodes that present fantastic technologies which not only entertain, but also predict future technologies, inspire people to create them, and may also engender fear in their audience.[103]

There are countless examples of technological inspiration from science fiction. Networked communication devices inspired by the communicator badges used in the fictional *Star Trek* television and motion picture franchises set in the twenty-fourth century are reality today: the American company Vocera markets a computer-controlled two-way communications device which responds to voice commands and may be worn as

[103] Singer, *Wired for War* …, 151, 156; and Springer, *Military Robots and Drones*…, 16–17.

a lapel pin.[104] Other fictitious *Star Trek* technological staples begat modern technology: tricorders are credited as the inspiration for the PalmPilot personal digital assistant.[105]

Industry and the research community use our familiarity with science fiction in marketing: Samsung recently marketed a wristwatch smart phone using clips from numerous old television series where familiar fictional characters used similar devices.[106] Also, capitalizing on the popularity of *Star Trek*, a United States Air Force (USAF) research project for a laser dazzler rifle which can be mounted on a robot gave it the acronym PHaSR in order to improve the project's chances of being funded.[107]

Science fiction has also predicted future military technology and tactics, as discussed earlier. In his book *Science Fiction (The New Critical Idiom)*, Adam Roberts relates how H.G. Wells foresaw tanks and the bombing of cities by aircraft.[108] Singer credits Wells with also forecasting lasers in 1898 and the atomic bomb in 1914.[109]

---

[104] Jim Nash, "Biohazard Lab Makes Real-Life *Star Trek* Communicator," Txchnologist (blog), 6 November, 2013, http://txchnologist.com/post/66181743997/biohazard-lab-makes-communicator-jean-luc-picard-might.

[105] Alan Handel and Julian Jones, "How William Shatner changed the world," directed by Julian Jones, broadcast on 21 October, 2006, quoted in Singer, *Wired for War …*, 162.

[106] Ina Fried, "Samsung Taps Dick Tracy and the Jetsons to Help Sell Its Galaxy Gear Watch," 6 October, 2013, http://allthingsd.com/20131006/samsung-taps-dick-tracy-and-the-jetsons-to-help-sell-its-galaxy-gear-watch/.

[107] *United Press International*, "Military develops a Star Trek-like phaser," 1 December, 2005, http://www.upi.com/Science_News/2005/12/01/Military-develops-a-Star-Trek-like-phaser/UPI-88721133463599/.

[108] Adam Roberts, *Science Fiction (The New Critical Idiom)*, 2nd ed. (London: Taylor and Francis, 2006), Kindle edition, 27.

[109] Singer, *Wired for War …*, 85, 156.

That is not to say science fiction authors' predictions are infallible. Roberts points out that while Jules Verne predicted travel to the moon, the U.S. did not use giant cannons as launch mechanisms to get there; and that Wells' prediction of world government has not come to pass.[110] Even so, today's military robots were predicted in a science fiction story. The protagonist of a light-hearted 1986 comedy movie entitled *Short Circuit* is a prototype armed telerobot;[111] barely twenty years later, TALON SWORDS armed telerobots were being tested in the field.[112] This suggests the possibility that some modern robotics developments were inspired by science fiction, like the Palm Pilots and wrist phones discussed above.

Therefore it may not be unreasonable to assume that someday, some state will create an analogue for a Terminator robot. Robotics and computer technology have clearly delivered much in recent history: robotic telepresence surgery is becoming commonplace for difficult surgeries like urologic procedures, and more and more automobiles are built with advanced computerized features like voice recognition.[113] The RCN has relegated paper charts and sextants to backup status in favour of electronic

---

[110] Roberts, *Science Fiction* …, 26.

[111] See S.S. Wilson and Brent Maddock, *Short Circuit*, DVD, directed by John Badham (1986; Chatsworth: Image Entertainment, 2011), generally. A concise description of the movie's storyline is found at IMDb, "Short Circuit (1986)," last accessed 19 July, 2014, http://www.imdb.com/title/tt0091949/.

[112] Springer, *Military Robots and Drones*…, 25.

[113] See Sutchin R. Patel and Gyan Pareek, "The History of Robotics In Urology," *Medicine & Health Rhode Island* 92, no. 10 (October 2009): 325–326. http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=44722671&site=ehost-live, 325–326; and, IHS Technology, Market Watch, "Voice Recognition Installed in More than Half of New Cars by 2019," 19 March, 2013, https://technology.ihs.com/427146/voice-recognition-installed-in-more-than-half-of-new-cars-by-2019.

charts compatible with GPS-fed electronic chart display and information systems.[114] In the modern world of popular technology where seemingly anything might be done from a smart phone with the right app, there can be great expectations of robotics; and potentially, great misconceptions as well. Arkin echoes this sentiment when he states:

> In the early days of robotics it was remarkable if one could accomplish anything with these ... limited machines. … However, as ... a series of successful accomplishments were achieved within the field, it became apparent, and often fueled [*sic*] by Hollywood imagery and science fiction, that now accompanying the job of a responsible roboticist was the role of expectation management. We now needed to convince people that they were *not* capable of doing everything imaginable, certainly in the near term.[115]

Oscar Handlin described the popularization of technology in 1965, framing the public perception of technologies that might be only completely understood by engineers and scientists:

> Since the explanation of the scientists was remote and incomprehensible, a large part of the population satisfied its need for knowing in its own way. Side by side with the formally defined science there appeared a popular science, vague, undisciplined, unordered and yet extremely influential. It touched upon the science of the scientists, but did not accept its limits. And it more adequately met the requirements of the people because it could easily accommodate the traditional knowledge to which they clung.[116]

The media may thus play a role in the inflated expectations discussed by Arkin. Abetted by a popular view of technology, some media outlets may be inadvertently

---

[114] Royal Canadian Navy, CFCD 130, *Canadian Navigation Manual*, 2nd ed. (Esquimalt: VENTURE, the Naval Officer Training Centre, 2010), 45–48.

[115] Arkin, *Governing Lethal Behavior*…, xi. Emphasis Arkin's.

[116] Oscar Handlin, "Science and Technology in Popular Culture," *Daedalus* 94, no. 1 (Winter 1965): 156–170, http://www.jstor.org/stable/20026900, 169.

distorting the public perception of robotics either through a misunderstanding of the field of robotics itself, or through taking creative or editorial licence. Heyns' 2013 report to the U.N. General Assembly clearly states that "robots with full lethal autonomy have not yet been deployed."[117] While some media outlets such as *The Telegraph* quoted that U.N. report accurately, others—including the *Canadian Broadcasting Corporation*, the *National Broadcasting Corporation* and *The Times of Israel*—confused guided weapons or semi-automatic or automatic modes of operation with autonomous systems.[118] Interestingly, a number of the articles surveyed for this paper also refer to or show pictures of a Terminator robot.[119]

Evil robots make for good fiction, and may generate fear of robots in general. In contrast to the light-hearted tone of *Short Circuit*, much science fiction portrays dystopian futures where lethal autonomous robots are antagonists. In 1953, long before James Cameron's *The Terminator* and its many sequels and spin-offs, celebrated science

[117] General Assembly, A/HRC/23/47, 8.

[118] See Harriet Alexander, "'Killer robots' could be outlawed," *The Telegraph*, 14 November 2013, http://www.telegraph.co.uk/news/worldnews/europe/10446724/Killer-Robots-could-be-outlawed html. Examples of inaccurate reporting include but are not limited to Associated Press, "UN report calls for killer robot moratorium," *CBC News*, 2 May 2013, http://www.cbc.ca/news/world/un-report-calls-for-killer-robot-moratorium-1.1386348; Nidhi Subbaraman, "'Terminator' on hold? Debate to stop killer robots takes global stage," *NBC News*, 21 October, 2013, http://www.nbcnews.com/#/tech/innovation/terminator-hold-debate-stop-killer-robots-takes-global-stage-f8C11433704; Peter James Spielmann, Associated Press, "Israeli killer robots could be banned under UN proposal," *The Times of Israel*, 3 May 2013, http://www.timesofisrael.com/israeli-killer-robots-could-be-banned-under-un-proposal/.

[119] Among others, Richard Norton-Taylor and Rob Evans, "The Terminators: drone strikes prompt MoD to ponder ethics of killer robots," *The Guardian*, 17 April 2011, http://www.theguardian.com/world/2011/apr/17/terminators-drone-strikes-mod-ethics; Subbaran, "'Terminator' on hold …;" Ed Pilkington, "'Killer robots' pose threat to peace and should be banned, UN warned," *The Guardian*, 29 May, 2013, http://www.theguardian.com/science/2013/may/29/killer-robots-ban-un-warning; and, Jeff Lacroix-Wilson, "Canada versus killer robots: Groups want federal government to lead charge against high-tech death machines," *Ottawa Citizen*, 28 April, 2014, http://www.ottawacitizen.com/technology/Canada+versus+killer+robots+Groups+want+federal+government/9788399/story.html.

fiction author Philip K. Dick wrote of lethal autonomous robots called *claws* that evolve, rebel against and set about eradicating their human masters, in his short story *Second Variety*.[120] The plot of a 1968 *Star Trek* television series episode revolves around an experimental autonomous combat management system fit to the USS ENTERPRISE that destroys an unmanned neutral freighter and attacks four friendly manned starships, killing or injuring their crews.[121] A Marvel comic book story arc written by Chris Claremont in 1980 entitled *X-Men: Days of Future Past* depicts a future in which lethal autonomous robot *Sentinels* subjugate the human race.[122] Finally, the antagonists in the modern television and motion picture series *Battlestar Galactica* are evil *Cylon* killer robots with a plan to eliminate their human creators.[123]

*Short Circuit*'s heroic robot notwithstanding, these examples support Paul Springer's contention that:

> The popular view of lethal, autonomous machines is almost uniformly negative. Hollywood has produced countless science fiction films with killer robots bent on the destruction of humanity ... these robots engendered fear in audiences, in part because they killed without emotion,

[120] Philip K. Dick, "Second Variety," in Turtledove, *The Best Military Science Fiction …*, locations 667–1600; the short story's original date of publication is found at location 11229 of the same book.

[121] See chaps. 3 and 5 of Gene Roddenberry, D.C. Fontana and Laurence N. Wolfe, "The Ultimate Computer," *Star Trek* Season Two Remastered DVD Edition, directed by John Meredyth Lucas (1968; Hollywood: CBS DVD, 2008).

[122] Chris Claremont, *X-Men: Days of Future Past*, 2nd ed., originally published in magazine form as *X-Men* no. 138–141, *Uncanny X-Men* no. 142-143 and *X-Men Annual* no. 4 (1980–1981; New York: Marvel Worldwide, 2014), 106–152.

[123] Summarized in n.a., "The Cylons of *The Plan,*" bonus feature, *Battlestar Galactica: The Plan*, DVD, directed by Edward James Olmos (Universal City, CA: Universal Studios Home Entertainment, 2009).

or remorse.[124]

Audiences might therefore be forgiven for lending dystopian science fiction stories some credence and fearing that some of the less fantastic aspects of the lethal autonomous robots they present could actually happen, given the modern conveniences inspired by science fiction stories and the accuracy of some author's predictions about revolutionary military technology. In a 2008 study conducted by Emma Hughes and Jenny Kitzinger of Cardiff University, people claimed to be able to intellectually discern fact from fiction and recognized that dystopian stories were more likely to make money than 'happy' science fiction; but they admitted they might be subconsciously or emotionally susceptible to it, and believed it influenced others as well.[125]

It must be noted that popular culture's fascination with military technology is not all about science fiction or bad news; sometimes it is about technological achievement with positive outcomes. The TALON SWORDS telerobot was hailed by *Time Magazine* as one the best inventions of 2004, because of its ability to relentlessly and stealthily hunt down insurgents.[126]

---

[124] Springer, *Military Robots and Drones…*, 50.

[125] Emma Hughes and Jenny Kitzinger, "Science Fiction Fears? An analysis of how people use fiction in discussing risk and emerging science and technology," (SCARR working paper 28-2008, Cardiff School of Journalism, Media and Cultural Studies, Cardiff University, Cardiff, Wales, 2008), http://www.kent.ac.uk/scarr/papers/HughesKitzingerWkPpr28.pdf, 16–17.

[126] *Time Magazine*, Best Inventions of 2004, "Robo-Soldier," last accessed 20 March 2014, http://content.time.com/time/specials/packages/article/0,28804,1940424_1940475_1940638,00.html.

Finally, Hughes and Kitzinger also point out that science fiction can allay fear of the future instead of amplifying it, when one considers the fantasy behind the fear.[127] However, while modern robotics technology does not reflect the predictions of earlier dystopian science fiction, at least one state government is concerned that unmanned military technology could lead states down that path.[128] The British Ministry of Defence's 2011 doctrine publication *The UK Approach to Unmanned Aircraft Systems*, warns "[t]here is a danger that time is running out – is debate and development of policy even still possible, or is the technological genie already out of the ethical bottle, embarking us all on an incremental and involuntary journey towards a *Terminator*-like reality?"[129] Clearly, popular culture influences the debate over lethal autonomous robots.

---

[127] Hughes and Kitzinger, "Science Fiction Fears…," 5.

[128] Adam Smith, "How close were the Terminator films to the reality of 2011?" *BBC News - Technology*, 21 April 2011, http://www.bbc.co.uk/news/technology-13159616; and, Norton-Taylor and Evans, "The Terminators …."

[129] UK MoD Joint Doctrine Note 2/11, 5-11–5-12.

# CHAPTER FIVE

## JUST WAR THEORY MEETS *MACHINIS AUTONOME*

*Let us never forget that our enemies are men.*
– Emmerich de Vattel, 1740.

*Listen, and understand. That terminator is out there. It can't be bargained with. It can't be reasoned with. It doesn't feel pity, or remorse, or fear. And it absolutely will not stop, ever, until you are dead.*
– Kyle Reese, *The Terminator*, 1984.

Earlier chapters of this paper provided a brief historical background of military robotics, outlined concerns about potential development of killer robots, defined LARs and discussed how popular culture may be influencing the debate over their use. This chapter examines LARs within the context of two branches of just war tradition.

The principles of *jus ad bellum* and *jus in bello* introduced earlier encompass several criteria. As described by James Turner Johnson in his book *Morality and Contemporary Warfare*, *jus ad bellum* allows military force to be employed by forces having *just cause*, *right authority* and *right intention*. There must be *proportionality of ends*—that is, the resulting good must outweigh the harm done by using military force—but even so, military force must be a *last resort* with a *reasonable expectation of success*. When employing that force, *jus in bello* dictates a need for *discrimination* and *proportionality of means*; in other words, non-combatants must not be intentionally harmed, and needless destruction must be avoided.[130] In a presentation to students of the Canadian Forces College, Walter Dorn adds the criteria of *right conduct*, characterized as

[130] These criteria of *jus ad bellum* and *jus in bello* are summarized in Johnson, *Morality* …, 27–29, 36. The criteria may have different names in some literature. For example, Johnson's criterion of *discrimination* is sometimes referred to as *distinction* by other authors.

respect for human rights; and *military necessity*, a complimentary or balancing criterion to proportionality of means, as elements of *jus in bello*.[131] Military necessity allows reasonable force to be employed to achieve a military objective.[132]

As discussed earlier, aspects of just war theory may be found in the U.N. Charter, the LOAC, and most rules of engagement (ROE). Dorn illustrates how the criteria of just cause, right authority, right intention, last resort, right conduct and intent of restoring peace are reflected in the U.N. Charter.[133] The principles of *jus in bello* may be found in IHL.[134] Proportionality of means is required by the Hague Conventions, and discrimination is expressed in the Geneva Conventions.[135] As implied by Johnson, international weapons treaties or customary practices meant to limit the proliferation or employment of specific classes of weaponry may be said to address *jus in bello* criteria, since they have the intrinsic effect of reducing harm.[136] The Ottawa Treaty banning land mines and the 2008 Convention on Cluster Munitions are examples of treaties aimed at eliminating or reducing the threat of non-discriminatory weapons, avoiding needless

---

[131] See Walter A. Dorn, "Just War Tradition and the Ethics of War," lecture presentation for Canadian Forces College Joint Command and Staff Programme (JCSP) 39, 4 September, 2012, http://walterdorn.net/pdf/JustWarTradition_Dorn_JCSP39_4Sept2012.pdf, 16; and, Nicholas Evans, "Emerging Military Technologies: A Case Study in Neurowarfare," chap. 6 in *New Wars and New Soldiers*, ed. Paolo Tripodi and Jessica Wolfendale (Farnham: Ashgate Publishing, 2011), 110–111.

[132] International Committee of the Red Cross. "The law of armed conflict – Lesson 1 – Basic Knowledge." Lecture presentation. June, 2002. http://www.icrc.org/eng/assets/files/other/law1_final.pdf, 13-1.

[133] Dorn, "Just War Tradition …," 27–28.

[134] See International Committee of the Red Cross, "IHL and other legal regimes – jus ad bellum and jus in bello," last updated 24 November, 2010, http://www.icrc.org/eng/war-and-law/ihl-other-legal-regmies/jus-in-bello-jus-ad-bellum/overview-jus-ad-bellum-jus-in-bello htm; and International Committee of the Red Cross, "War and international humanitarian law." Last updated 3 July, 2014, http://www.icrc.org/eng/war-and-law/.

[135] Johnson, *Morality* …, 30, 36.

[136] *Ibid.*, 30.

destruction, respecting the human rights of non-combatants and limiting the military necessity of using such weapons.[137]

The Canadian Armed Forces defines rules of engagement as "[o]rders issued by competent military authority which delineate the circumstances and limitations within which force may be applied to achieve military objectives in furtherance of national policy."[138] ROE can be a subset of the LOAC, and may also impose additional restrictions on the use of force beyond it.[139]

Among other things, ROE can provide orders that restrain or constrain a combatant's decision of when to use what force against a target.[140] That decision can be made through a decision-making process know as an *OODA loop,* devised by American military strategist John Boyd and described as "a cornerstone of [U.S.] fighter aviation."[141] The OODA loop is a closed-loop process that involves observation, orientation, deciding and acting. Observation is sensing what is happening; orientation is

---

[137] See International Committee of the Red Cross, "Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on their Destruction, 18 September 1997 – Preamble," last accessed 28 July, 2014, http://www.icrc.org/applic/ihl/ihl nsf/Article.xsp?action=openDocument&documentId=D4526D1EB0F4AF1241256585003DD6A1; and, United Nations Office at Geneva, "Diplomatic Conference for the Adoption of a Convention on Cluster Munitions," 30 May, 2008, http://www.unog.ch/80256EDD006B8954/(httpAssets)/CE9E6C29A6941AF1C12574F7004D3A5C/$file/ccm77_english.pdf, generally.

[138] Department of National Defence, B-GJ-005-501/FP-001 *Canadian Forces Joint Publication CFJP-5.1, Use of Force for CF Operations* (Ottawa: DND Canada, 29 August 2008), GL-4.

[139] Corn *et al.*, *The Law of Armed Conflict* …, 127, 192.

[140] *Ibid.*, 161, 193–194.

[141] Michael W. Byrnes, "Nightfall: Machine Autonomy in Air-to-Air Combat," *Air & Space Power Journal* 28, no. 3 (May-June 2014): 48–75, http://www.airpower.maxwell.af.mil/digital/pdf/articles/2014-May-Jun/F-Byrnes.pdf, 57.

processing or assessing what was sensed, based on a variety of factors; a decision is then made, based on that assessment; an action is taken; and the process repeats with new observations including the effects of the previous action.[142]

While *jus ad bellum* is meant to provide a framework for deciding whether or not to go to war,[143] aspects of that framework may be affected by an ability to employ LARs. Conventional wars can require a tremendous investment in lives, money and time. However, inexpensive LARs that bring about a quick victory with fewer casualties might desensitize a state and its government towards military conflict, subverting just cause and right intention because armed aggression is easier to justify.[144]

Right authority may be compromised at the strategic level if non-state actors obtain LARs, just as Hamas obtained drones as discussed earlier, as armed conflict would no longer be confined to states.[145] However, it might be maintained at the operational or tactical level, if LARs could be verifiably programmed with robust ROE. Regardless of how feasible such programming may be at present, as Makin states, "[r]esponsibility still rests with the authorising authority to ensure that the soldier or autonomous system is properly trained, tested and or evaluated and suitably equipped to conduct the specific

---

[142] Grant T. Hammond, "On The Making of History: John Boyd and American Security," (Harmon Memorial Lecture, United States Air Force Academy, Colorado, 2012), http://www.usafa.edu/df/dfh/docs/Harmon54.pdf, 8–10.

[143] Corn *et al.*, *The Law of Armed Conflict* …, 2.

[144] n.a., "Robotic warfare drawing nearer," *Washington Times*, 9 February 2005, http://www.washingtontimes.com/news/2005/feb/9/20050209-113147-1910r/?page=all.

[145] Thomas H. Cowan, "A theoretical, legal and ethical impact of robots on warfare," Masters of Strategic Studies Paper, United States Army War College, 30 March, 2007, http://www.dtic mil/dtic/tr/fulltext/u2/a469591.pdf, 8.

mission or task."[146] An alternative is to only employ LARs in unambiguous circumstances as in the earlier discussion of automatic-mode CIWS employment; this will be explored further in chapter eight.

Conflict that is cheaper in lives, dollars or other political capital as discussed above could also prompt states with LARs to strike first—that is, be the aggressor in a conflict. Such an action may give credence to Johnson's contention that the first use of force is the greatest evil under contemporary international law and fail the criterion of last resort and proportionality of ends.[147] The cheap conflict argument also applies to the criteria of last resort, particularly in the context of asymmetric warfare. Political scientist Daniel R. Brunstetter contends that the inexpensive nature of drone warfare has prompted the U.S. government to claim their ongoing use in pre-emptive strikes against terrorists is a last resort tactic, potentially allowing the use of American drones anytime and anywhere.[148]

On a more positive note, Robert Sparrow notes that at the tactical or operational level this same low cost might make LARs highly suitable for attacks against objectives that are nigh-impossible to overcome—attacks with strong potential to become suicide

[146] N.S. Makin, "Future warfare or folly? Autonomous weapon systems on the battlefield: an assessment of ethical and legal implications in their potential use," (Masters of Defence Studies Paper, Canadian Forces College, 2008), 27.

[147] Johnson, *Morality* …, 28–30.

[148] Daniel R. Brunstetter, "Can We Wage a Just Drone War?" *The Atlantic*, 19 Jul, 2012, http://www.theatlantic.com/technology/archive/2012/07/can-we-wage-a-just-drone-war/260055/.

attacks—without resorting to lengthy or costly attrition warfare by manned forces.[149] Risky missions such as the frigate HMS ALACRITY's mine-hunting foray up Falkland Sound during OPERATION CORPORATE in 1983 could be conducted by an autonomous maritime unmanned system, avoiding the potential cost in lives and equipment that would resulted if the ship had struck a mine.[150] As a final speculative comment on last resort, LARs might also be justifiable as a last resort in a defensive scenario where manned defences are clearly insufficient.

LARs possessing high targeting accuracy such as that ascribed to TALON SWORDS earlier in this paper, as well as robust ROE, might ensure a reasonable expectation of success employed against forces not possessing their own LARs. But this begs the question if proportionality of ends can ever be balanced, when LARs are involved on only one side of a conflict?[151]

With respect to *jus in bello*, Bekey addresses right conduct when he asks "[if] a robot enters a structure, how can we be sure that it will not violate the rights of human occupants?"[152] ROE might address specific situations in that regard, particularly if LARs could observe and orient their decision-making processes towards objects or facts associated with specific cultural, religious or other rights of an enemy. Consider, as an

[149] Robert Sparrow, "Robotic Weapons and the Future of War," chap. 7 in *New Wars and New Soldiers*, ed. Paolo Tripodi and Jessica Wolfendale (Farnham: Ashgate Publishing, 2011), 120.

[150] HMS ALACRITY's mission is recounted in Sandy Woodward and Patrick Robinson, *One Hundred Days: The Memoirs of the Falklands Battle Group Commander*, 3rd ed. (London: HarperPress, 2012), Kindle Edition, 277–283.

[151] Cowan, "A theoretical, legal and ethical impact …," 6–8.

[152] Bekey, "Current Trends in Robotics …," 32.

example, a rule of engagement that forbids encroachment on a recognized holy site: LARs might be programmed to avoid entering a structure displaying one or more specific religious symbols. However, as Sparrow argues, unprecedented amounts of raw data and processing power might be required to address all but the most obvious potential violations of human rights not related to non-combatant protection or immunity.[153] Further, Dorn argues that such ROE "could be massively misused by [an] opponent—[who paints] a crescent on every door, a cross on every entrance."[154] Clearly, a LAR's ability to respect human rights is problematic.

Proportionality of means could be served by the high accuracy of LARs discussed earlier. It can also be addressed by ensuring LARs are equipped only with weaponry appropriate to the task at hand. LARs being sent on sniper missions should probably be equipped with sniper rifles instead of machine guns. The Modular Advanced Armed Robotic System (MAARS), a military telerobot developed from the TALON SWORDS robot discussed earlier, provides for use of a variety of non-lethal and lethal weapons as well as escalation of force from simple audible and visual warnings, through non-lethal weapons, to lethal weaponry, under operator control.[155] LARs might therefore also be equipped with a range of lethal and non-lethal weapons or ammunition, and programmed to employ either escalating force or the most appropriate and least-lethal or least-destructive means to prosecute a target in a given scenario.

---

[153] Sparrow, "Robotic Weapons …," 122.

[154] Dorn, email message to author, 12 June, 2014.

[155] See QinetiQ North America, "MAARS," last accessed 19 May, 2014, https://www.qinetiq-na.com/products/unmanned-systems/maars/; and, QinetiQ, "QinetiQ North America Ships First MAARS Robot," 5 June, 2008, http://www.qinetiq.com/media/news/releases/Pages/qna-ships-first-maars-robot.aspx.

Military necessity might be served by detailed operational programming and ROE that inhibit a LAR's decision to fire on anything that is not clearly a military objective. But such a capability would be affected by the same targeting concerns in the discussion of right conduct above, and may still be a long way off. Arkin devotes two chapters of his book *Governing Lethal Behaviour in Autonomous Robots* to conceptual design of a robotic processor that includes an ethical behaviour control and an ethical governor, meant to constrain and restrain lethal responses against unauthorized targets; however, he acknowledges that assessing military necessity once deployed is an outstanding problem requiring its own line of research.[156] Additionally, in a recent editorial for the *Ottawa Citizen* newspaper preceding the Canadian debut of the Campaign to Stop Killer Robots, Ian Kerr casts doubt on the ability of software algorithms to make moral decisions.[157]

Discrimination is a key issue in discussions about LARs because a fully autonomous robot would be executing the OODA loop on its own, making its own decision to fire its weaponry.[158] Collateral damage due to inaccurate aim does not appear to be a concern: in 1999, Johnson noted that contemporary guided weapons represented an improvement in militaries' ability to observe *jus in bello* due to their accuracy.[159] This

---

[156] Arkin, *Governing Lethal Behavior*…, 115–153 generally, and 126.

[157] Ian Kerr, "Keep killer robots fictional," *Ottawa Citizen*, 26 April, 2014. http://www.ottawacitizen.com/opinion/op-ed/Keep+killer+robots+fictional/9780860/story html.

[158] Anthony J. Lazarski, "Legal Implications of the Uninhabited Combat Aerial Vehicle," *Aerospace Power Journal* 16, no. 2 (Summer 2002): 74–83, http://www.airpower.maxwell.af mil/airchronicles/apj/apj02/sum02/sum02.pdf, 81.

[159] Johnson, *Morality* …, 34–35.

would seem to be borne out by the claims of TALON SWORDS' accuracy discussed earlier.

The true dilemma faced in determining whether or not LARs should be entrusted with power over human life or death in battle is succinctly alluded by S.Y. Harmon and D.W. Gage in a paper for the Institute of Electrical and Electronics Engineers' 17th Annual Electronics and Aerospace Conference in 1984: "[i]n military operations quite bizarre situations can be encountered. For example, how should an infantry robot be programmed to discriminate between a deaf nun and a Soviet soldier pretending to be a deaf nun?"[160] Noel Sharkey makes a similar point in a 2012 *Daily Mail* newspaper article, arguing that "machines would struggle to distinguish between a child holding an ice-cream cone and a man with a gun, leading to the indiscriminate loss of civilian life."[161]

A host of factors influence human combatants' ability to comply with the law of armed conflict in combat, including—but not necessarily limited to—time pressure, limited situational awareness, varying personal commitment, fear of self-sacrifice or consequences, social biases and the chaos of the battlefield.[162] Some argue that LARs will not have these weaknesses: in a study entitled *Autonomous Military Robotics: Risk, Ethics, and Design* prepared for the U.S. Office of Naval Research (ONR), Patrick Lin,

---

[160] Harmon and Gage, "Current technical research issues …," 216.

[161] Noel Sharkey, interviewed in "Video game aces 'will wage wars of the future using killer robots,'" *The Mail Online*, 24 February, 2012, http://www.dailymail.co.uk/sciencetech/article-2283941/Video-game-aces-wage-wars-future-using-killer-robots.html.

[162] Sparrow, "Robotic Weapons …," 123.

George Bekey and Keith Abney argue that not only would LARs' lack of emotion make them less likely to violate ROE or the LOAC due to stress and other such factors, but their ability to observe and record behaviour on the battlefield would reinforce the ethical behaviour of others on the battlefield.[163] They speculate that "[w]ith a properly programmed slave morality, a robot can ensure it will not violate the LOW or ROE."[164]

But not everyone agrees. Robotics specialist and former military pilot Dr Missy Cummings of MIT states that the nuances that may distinguish friends from foes are potentially too complex for a robot to process.[165] Sparrow echoes this, pointing out that abstract judgement and an appreciation of context are necessary in addition to the vast amounts of data and processing power discussed earlier.[166] Finally, Arkin admits that autonomous discrimination of combatants and non-combatants in combat, as well as an ability to discern when a legitimate target becomes *hors de combat*, are significant outstanding lines of research.[167] Such abilities may still be science fiction, thirty years after they were broached by Harmon and Gage as discussed above.

In examining the ethical debate it is important to note that it is not a debate in absolutes. Just war theory covers a spectrum of philosophies that leaves room for

---

[163] Patrick Lin, George Bekey and Keith Abney, "Autonomous Military Robotics: Risk, Ethics, and Design," funded by the U.S. Department of Defense/Office of Naval Research, 20 December, 2008, http://ethics.calpoly.edu/ONR_report.pdf, 1.

[164] *Ibid.*, 54.

[165] Gabriel Miller, "Smart enough to kill?" *C4ISR* (June 1, 2013): 14; www.proquest.com.

[166] Sparrow, "Robotic Weapons …," 122.

[167] Arkin, *Governing Lethal Behavior*…, 126.

interpretation and application to a variety of scenarios.[168] Similarly, proponents of LARs do not maintain that their programming or artificial intelligence will allow them to consistently make infallible ethical choices; rather, they maintain that LARs will simply out-perform human military personnel in that regard.[169]

The Hague and Geneva Conventions mentioned are two of many legal instruments codifying principles of just war theory, among other considerations, as treaty law.[170] The Hague Conventions and Declarations, meant to constrain and restrain the conduct of warfare, cover various topics including but not limited to identification of combatants, treatment of prisoners of war, prohibited weapons, commencement of hostilities, neutrality and many aspects of naval warfighting; the Geneva Conventions address protection of non-combatants.[171] Of note, articles 86 and 87 of Additional Protocol I to the Geneva Conventions establishes commanders' responsibility for forces they command;[172] if a LAR is part of that force, command responsibility is clear.

IHL also provides for circumstances not explicitly found in treaties. In such cases, a provision known as the Martens Clause, found in Additional Protocol I to the Geneva

---

[168] Dorn, "Just War Tradition …," 11, 17.

[169] Arkin, *Governing Lethal Behavior*…, 30–31; and Lin, Bekey and Abney, "Autonomous Military Robotics …," 2, 54.

[170] A collection of treaties applicable to armed combat is found at International Committee of the Red Cross, "Treaties and States Party to Such Treaties," last accessed 20 Jun, 2014, http://www.icrc.org/applic/ihl/ihl nsf/vwTreatiesByDate.xsp.

[171] *Ibid*., generally; and International Committee of the Red Cross, "The law of armed conflict – Lesson 1…," 9-1.

[172] United Nations, Protocol Additional to the Geneva Conventions of 12 August 1949, and relating to the protection of victims of international armed conflicts (Protocol I), 8 June, 1977, 1125 U.N.T.S. 17512. Available at https://treaties.un.org/doc/Publication/UNTS/Volume%201125/volume-1125-I-17512-English.pdf, 42–43.

Conventions, states that people "remain under the protection and authority of the principles of international law derived from established custom, from the principles of humanity and from the dictates of public conscience."[173]

A more recent treaty, the 2001 Convention on Certain Conventional Weapons (CCW), prohibits or limits specific classes of weaponry deemed to violate the principles of discrimination, proportionality and right conduct.[174] LARs have gained sufficient notoriety that they were the subject of a four-day session at the recent 2014 CCW meeting.[175] Participants affirmed the inability of modern and emerging technology to support the qualitative decision-making necessary to apply the LOAC in the chaos of combat, calling for a ban on LARs or maintenance of human control over them.[176]

In closing, the arguments in this chapter may seem disjointed in presentation; however they serve to illustrate the breadth of the ethical and legal considerations as well as the variety of interests, values, moral philosophies and resulting perspectives involved.[177] Since LARs do not yet exist, it remains to be seen how their employment

---

173 United Nations, Protocol Additional to the Geneva Conventions of 12 August 1949 …, 7.

174 United Nations Office at Geneva, "The Convention on Certain Conventional Weapons," last accessed 20 June, 2014, http://www.unog.ch/80256EE600585943/(httpPages)/4F0DEF093B4860B4C1257180004B1B30?OpenDocument.

175 United Nations Office at Geneva, "CCW – Latest Information," last accessed 20 June, 2014, http://www.unog.ch/80256EE600585943/(httpPages)/3CFCEEEF52D553D5C1257B0300473B77?OpenDocument.

176 United Nations Office at Geneva, "Advanced version – Report of the 2014 informal Meeting of Experts on Lethal Autonomous Weapons Systems (LAWS)," last accessed 20 June, 2014, http://www.unog.ch/80256EDD006B8954/(httpAssets)/350D9ABED1AFA515C1257CF30047A8C7/$file/Report_AdvancedVersion_10June.pdf, 3–5.

177 Dorn, "Just War Tradition …," 3–5, 7–12, 17, 20–25.

would satisfy just war theory's criteria in practice.[178] This chapter has highlighted concerns over discrimination and proportionality that may not be addressed in the foreseeable future, as well as issues related to responsibility and the use of LARs as a last resort.

The next three chapters will examine doctrine related to similar weapons, as well as accidents and mishaps that inform the debate; discuss the positions of the U.N., governments, non-governmental organizations and other parties; and explore potential solutions to the question of LAR employment doctrine.

[178] General Assembly, A/HRC/23/47, 8, 20.

# CHAPTER SIX

# THE SHAPE OF THINGS TODAY

*Error ... Error ... Error! Examine!*

– NOMAD robot, *"*The Changeling,*" Star Trek,* 1967.

This paper's initial chapters provided a brief overview of the state of modern robotic weapons technology, with attention to semi-automatic and automatic-capable combat systems as well as unmanned military robotic systems. Those systems are tele-operated or pre-programmed to execute specific actions in response to specific commands, sensor inputs or combinations thereof; they lack an ability to generate unique responses without some form of operator input.[179] The current state of research and development of robotics technology is summarized by the U.S. Department of Defense in its *Unmanned Systems Integrated Roadmap FY 2013-2038* as "advancing from a state of automatic systems requiring human control toward a state of autonomous systems able to make decisions and react without human interaction."[180]

The *Unmanned Systems Integrated Roadmap* also points out that robotic systems are only as good as their programming, and that effective execution of the OODA loop by a robotic system requires analysis, understanding and training.[181] This implies a need for effective doctrine in military robotic systems—both modern tele-operated or automatic systems and possibly tomorrow's autonomous systems.

---

[179] Department of Defense, 14-S-0553, *Unmanned Systems Integrated Roadmap FY 2013-2038*, 66.

[180] *Ibid.*, 68.

[181] *Ibid.*, 67.

Retired USAF Major General I.B. Holley Jr. describes *doctrine* in the military context as follows:

> [D]octrine is what is officially approved to be taught … about what methods to use to carry out a military objective … For the most part, doctrine is derived from past experience; it reflects an official recognition of what has usually worked best from observation of numerous trials. These may be reports of actual combat operations, or they may be limited to tests, exercises, and maneuvers.[182]

The Canadian Armed Forces definition of doctrine states that judgement also plays a role in doctrine.[183] Modern military weapons employment doctrine strives to safely and effectively execute the OODA loop in a contemporary environment of high-speed threats and guided weapons, as discussed earlier in this paper.[184] It does this through a combination of risk avoidance strategies and positive control measures that can vary from one type of weapon system to the next.

Holley's definition above implies that experience with equipment and operations is necessary to develop doctrine. The detailed development of LAR employment doctrine may therefore have to wait until there are sufficient observations from LAR tests and trials to inform the constraints and restraints of using killer robots. However, experience with past and current military robotic systems may provide a useful starting point,

---

[182] I.B. Holley, Jr., "The Role of Doctrine," chap. 1 in *Technology and Military Doctrine: Essays on a Challenging Relationship* (Maxwell AFB, Alabama: Air University Press, August 2004), http://aupress maxwell.af mil/digital/pdf/book/b_0093_holley_technology_military_doctrine.pdf, 1–2.

[183] Defence Terminology Bank, record 1761, last accessed 10 Jane, 2014, http://terminology mil.ca/term-eng.asp.

[184] See also Alex Borgeit, "Eliminating the 'You' in UMV," United States Naval Institute, last accessed 14 May, 2014, http://www.usni.org/eliminating-%E2%80%9Cyou%E2%80%9D-umv.

informed by doctrine for those systems as well as lessons from accidents and mishaps associated with them. Towards that end, this chapter will briefly discuss aspects of modern weapons employment doctrine, and then examine various accidents and mishaps associated with contemporary military robotic systems.

Modern operational battlespace management doctrine such as waterspace or airspace management, and land-based risk avoidance practices such as marking mine danger areas, all prescribe *warning zones* which instruct military forces and civilians to avoid entering those areas at risk of collision, injury or death. Land minefields may be marked in a variety of ways, to encourage people—friend, foe or non-combatant alike—to stay out of a known or suspected mine danger area.[185] Paraphrasing Commander Timothy C. Young in a paper for the United States Naval War College, the premise behind a warning zone is simple: those who stay out of a warning zone should be safe from whatever is or happens inside it.[186]

In the air defence realm, the U.S. Army's field manual on UAV employment describes airspace management as a means of safely de-conflicting aircraft while supporting air defence in a given area of operations.[187] The field manual also describes a

---

[185] United Nations Mine Action Service, Landmine and Explosive Remnants of War Safety Handbook, 2nd ed. (New York: United Nations, 2005), http://www.mineaction.org/sites/default/files/publications/Landmine_and_ERW_Safety_Handbook_0.pdf, 33–36, 57–58. UN standards for minefield marking are found at United Nations, International Standards for Humanitarian Mine Clearance Operations, "Section Four – Minefield Marking," last accessed 15 May 2014, http://www.un.org/Depts/mine/Standard/chap_4.htm.

[186] Timothy C. Young, "Maritime Exclusion Zones: A Tool for the Operational Commander?" Final course paper, United States Naval War College, 18 May, 1992, http://www.dtic.mil/dtic/tr/fulltext/u2/a253218.pdf, 1–2.

[187] United States Army, FM 34-25-2, "Airspace Management," Chap. 3 of *Unmanned Aerial Vehicles Test Draft*, Jun 95, https://www.fas.org/irp/doddir/army/fm34-25-2/25-2ch3.pdf, 3-1.

restricted operating zone (ROZ), where aircraft not related to the mission at hand may be prohibited during UAV operations.[188] The United States Air Force Research Laboratory has demonstrated software that—given access to all relevant weapons systems information—de-conflicts air operations and weapons trajectories in a joint operating area using a laptop computer.[189]

In naval warfare, operational doctrine such as prevention of mutual interference (PMI) and waterspace management exist to mitigate the risk of collisions between submerged submarines, and prevent blue-on-blue engagements between submarines and anti-submarine warfare forces, respectively.[190] Additionally, a maritime exclusion zone (MEZ) may be used by a state during an armed conflict.[191] MEZs evolved from naval blockades as a means to control large areas of the sea using sea mines, submarines or aircraft—and modern weapons systems—as force multipliers.[192] Typically announced through Notices to Airmen (NOTAMs) and Notices to Mariners (NOTMARs), MEZs identify operating areas where enemy forces—or other aircraft or vessels entering an

---

[188] *Ibid.*, 3-1.

[189] DiLego, Francis A. Jr. *et al.*, "Joint Airspace Management and Deconfliction (JASMAD)." AFRL-RI-RS-TR-2009-13 Final In-House Technical Report (Rome, N.Y.: Air Force Research Laboratory, January 2009), http://handle.dtic.mil/100.2/ADA493585, 4, 8–9, 25–27.

[190] Christopher J. Kelly, "The submarine force in joint operations," Air Command and Staff College Research Report AU/ASC/145/1998-04, Air University, April 1998, https://www.fas.org/man/dod-101/sys/ship/docs/98-145.pdf, 33–34.

[191] Young, "Maritime Exclusion Zones …," 1–2.

[192] *Ibid.*, 3–5; and Christopher Michaelsen, "Maritime Exclusion Zones in Times of Armed Conflict at Sea: Legal Controversies Still Unresolved," *Journal Of Conflict & Security Law* 8, no. 2 (October 2003): 363–390, http://search.ebscohost.com/login.aspx?direct=true&db=tsh&AN=44546855&site=ehost-live, 363–364.

area—may be targeted.[193] An MEZ might be enforced by a ship or ships with automated combat management systems.

There are several examples of MEZs being employed throughout the twentieth century.[194] They are relevant to the discussion of robotic systems because MEZs may simplify the challenge of discrimination in remote or autonomous targeting, since any non-allied contact found in an exclusion zone may be considered a legitimate target.[195] However, that consideration violates the right of innocent passage for neutral parties, as when both sides of the 1980's Iran-Iraq War sank neutral commercial ships for violating declared MEZs.[196] Overzealous targeting causing great accidental loss of innocent life can have great adverse military, political and diplomatic consequences, as summed up by Admiral Sir Sandy Woodward in his memoire of OPERATION CORPORATE when describing an encounter with a neutral Brazilian airliner in 1982: he felt the Falklands War would have been lost, had the airliner been shot down.[197] Finally, Young also

---

[193] Michaelsen, "Maritime Exclusion Zones in Times of Armed Conflict …," 366; and Young, "Maritime Exclusion Zones …," 1.

[194] See Michaelsen, "Maritime Exclusion Zones in Times of Armed Conflict …," 367–376; and Young, "Maritime Exclusion Zones …," 2–7.

[195] Young, "Maritime Exclusion Zones …," 8–10.

[196] Michaelsen, "Maritime Exclusion Zones in Times of Armed Conflict …," 366, and Young, "Maritime Exclusion Zones …," 5, 14–15.

[197] Woodward and Robinson, *One Hundred Days…*, 143–144. Although the dilemma facing Woodward in this situation was about balancing the defence of his task force against the restraints of his ROE, the key point here is the impact of overzealous targeting.

identifies an additional weakness of MEZs by pointing out that declaring an MEZ may identify a friendly centre of gravity, allowing an enemy to focus its efforts accordingly.[198]

At the tactical level, weapons drills include the use of computer-generated safety firing arcs to provide assurance that friendly or non-combatant forces are outside the reach of the weaponry.[199] Modern naval combat procedures provide multiple layers of human interaction in the OODA Loop to ensure that ROE are respected and rounds go on target as they are intended to.[200] Automated combat management systems can also be so programmed: as early as the 1980's it was possible to program a combat management system's threat evaluation and weapons assignment subsystem to respond to specific threats with specific weapons, or limit a combat management system's range of weapon employment options within predefined zones.[201]

Notwithstanding the automation of modern naval combat systems, commanders and their crews maintain a degree of control over a ship's automated weapons through the use of manual electrical switches meant to allow them to either permit or inhibit weapon operation. Such switches are known as *firing keys* and *veto switches*, respectively. Firing keys in this context are electrical dead man switches which, when closed, permit the firing of an electrically-controlled weapon. The Gunar/Mk 69 Gun Fire Control System was a surface and anti-aircraft gun direction system common to most of the RCN's ships

---

[198] Young, "Maritime Exclusion Zones …," 12.

[199] See generally, Royal Canadian Navy, Maritime Command Order 46-3, "Safety Firing Orders for Ships and Submarines," September 2009.

[200] Borgeit, "Eliminating the 'You' …."

[201] Frieden, *Principles of Naval Weapons Systems*, 574.

in the 1980's; it had several firing keys, each of which would inhibit firing of the ship's guns if its holder released it.[202] Veto switches are switches which make a weapon electrically safe—that is, inhibit firing via electrical cut-out—when they are activated. Veto switches are commonly used with most shipboard weapons in modern RCN warships.[203]

Although doctrine and safety procedures are in place *inter alia* to reduce or prevent accidents and mishaps,[204] they can and do happen. The field of military robotics has been no exception to this rule. While exact details of such incidents may often be classified for reasons of military operational security, general information on some significant examples is available from open sources.

The Iraqi missile attack on USS STARK in 1987 succeeded in part due to the ship's CIWS being left in manual mode, as discussed earlier in this paper. But even in manual mode, the system's search radar should have detected an incoming target and provided a warning indication which would have allowed an operator to fire the weapon, suggesting a CIWS malfunction.[205]

---

[202] Firing keys are discussed in Maritime Command, *Gunar/Mk 69 Drill Book* (Halifax: Weapons Division, Canadian Forces Fleet School, 1982), quoted in the author's course notes for Maritime Engineering Phase III Afloat Training Requirement 430 (no title), Summer 1986; and, Maritime Command, *Naval Engineering Information* (Esquimalt: VENTURE, the Naval Officer Training Centre, nd.), 10-5, reproduced in the same course notes.

[203] The use of veto switches to make naval weapons safe is discussed in Royal Canadian Navy, Maritime Command Order 46-3, "Safety Firing Orders for Ships and Submarines," 4/38, 26/38–28/38.

[204] *Ibid*., generally.

[205] Friedman, *The Naval Institute Guide* …, 495; and Associated Press, "Ship's anti-missile system may not have worked properly," *Wilmington Morning Star*, 23 May, 1987,

Little over a year later in the summer of 1988, USS VINCENNES—nicknamed 'the Robocruiser' after the contemporaneous movie *RoboCop*, because of its state of the art robotic Aegis weapon system[206]—mistakenly downed Iran Air Flight 665 with two Standard surface-to-air missiles, killing 290 passengers and crew.[207] In his book, *Inside the Danger Zone: The U.S. Military in the Persian Gulf*, Harold Lee Wise recounts that in the heat of battle, a mistaken or incorrect Identification Friend or Foe (IFF) code led VINCENNES to believe that a civilian Airbus—initially assumed to be an unknown enemy aircraft in accordance with doctrine—was a hostile Iranian F-14 fighter closing on their position.[208] Seconds later, an eleven-second tactical data link glitch caused VINCENNES' Aegis system to report the suspected F-14 as diving on an attack profile.[209] With no response to numerous radio warnings broadcast to the plane, VINCENNES' captain ordered it shot down; the engagement had lasted a little over three minutes.[210] Wise states that the Aegis system was not at fault, as it tracked and targeted the Airbus correctly; however, he also notes the data link problem that caused Aegis to

---

http://news.google.com/newspapers?nid=1454&dat=19870523&id=14FRAAAAIBAJ&sjid=6RMEAAAAIBAJ&pg=5630,3256654, 6A.

[206] Wise, *Inside the Danger Zone…*, locations 4647–4654. The original *RoboCop* movie was released the previous year; see IMDb, "RoboCop (1987)," last accessed 4 June, 2014, http://www.imdb.com/title/tt0093870/.

[207] Wise, *Inside the Danger Zone…*, locations 4630–4631, 4810–4814.

[208] *Ibid.*, locations 4740–4753. IFF is an automated system that identifies aircraft.

[209] *Ibid.*, locations 4763–4777.

[210] *Ibid.*, locations 4790–4795, 4805–4808.

misreport the contact.[211] Had the contact not been misreported, the Airbus might not have been shot down.

Examples of accidents and mishaps are not confined to naval systems. During OPERATION IRAQI FREEDOM, the 2003 U.S.-led invasion of Iraq, automated U.S. Army AN/MIM-104 Patriot missile batteries deployed for ballistic missile defence erroneously shot down two friendly coalition aircraft, resulting in three deaths.[212] The Patriot systems successfully attacked all nine ballistic missiles they were fired against in an operations area so cluttered with contacts that a Department of Defense report on the missile systems' performance described it as having "a 4,000-to-1 friendly-to-enemy [airborne contact] ratio."[213] Problems with IFF, a lack of situational awareness and inadequate operating doctrine that relied too much on the system's automation were cited as contributing to the fratricide incidents.[214] The report summary recommended, among other things, that "[a] protocol that allows more operator oversight and control of major system actions will be needed."[215]

---

[211] *Ibid.*, locations 4780–4781, 4765–4776.

[212] Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, *Report of the Defense Science Board Task Force on Patriot System Performance – Report Summary* (Washington: Department of Defense, January, 2005), http://www.acq.osd.mil/dsb/reports/ADA435837.pdf, 1–2.

[213] *Ibid.*, 1–2.

[214] *Ibid.*, 2. Although outside the scope of this paper, it is curious to note that IFF problems played a role in both the VINCENNES and Patriot tragedies.

[215] *Ibid.*, 3.

In 2007, TALON SWORDS became the first armed telerobot to be deployed in theatre.[216] By 2008, media reports had surfaced about various problems with the system including possible unintended targeting of friendly soldiers, which led to stories of it being withdrawn from service or relegated to use as a static defence position, citing concerns over safety and confidence in the equipment.[217] TALON SWORDS was superseded by the MAARS telerobot mentioned in the previous chapter.[218] While discussion of TALON SWORDS problems should be tempered with recognition of the fact that it was an experimental or developmental robotic system, it is noteworthy that the U.S. Army initially had enough confidence in the system to conduct an operational evaluation of it in theatre. That this unmanned ground vehicle's employment was restricted to static defence may demonstrate a subsequent loss of confidence in the system's performance.

Accidents or mishaps involving armed unmanned vehicles are not necessarily all attributable to the robots themselves. In 2011, in what was described as the first Royal Air Force (RAF) Reaper strike causing civilian casualties, a strike on a pair of vehicles in Afghanistan killed two insurgents and four civilians travelling with them; an

---

[216] Popular Mechanics, "The Inside Story of the SWORDS Armed Robot "Pullout" in Iraq: Update," October 1, 2009, http://www.popularmechanics.com/technology/gadgets/4258963.

[217] Eric Sofge, "Non-Answer on Armed Robot Pullout From Iraq Reveals Fragile Bot Industry," *Popular Mechanics*, 1 October, 2009, http://www.popularmechanics.com/technology/gadgets/4258103; Lewis Page, "US war robots in Iraq 'turned guns' on fleshy comrades," *The Register*, 11 April, 2008, http://www.theregister.co.uk/2008/04/11/us_war_robot_rebellion_iraq/; and Sharon Weinberger, "Armed Robots Still in Iraq, But Grounded (Updated)," *Wired*, 15 April, 2008, http://www.wired.com/2008/04/armed-robots-st/.

[218] See note 155.

investigation found fault with bad intelligence, as opposed to the drone or its operators.[219] An un-named government source told *The Guardian* that "[t]he attack would not have taken place if we had known that there were civilians in the vehicles as well."[220] In a paper for the *International Review of the Red Cross*, Stuart Casey-Maslen speculates that the insurgent targets were probably valid under the LOAC but the presence of the civilians would have failed the test of proportionality in the eyes of the United Kingdom.[221] The situation begs the question of how LARS might recognize the non-combatants and arrive at the same conclusion about proportionality in a similar situation.

Drone accidents and mishaps in the USAF have outpaced those of its manned aircraft: a 2012 study by *Bloomberg Government* stated that Predator, Reaper and Global Hawk alone had a combined accident rate three times higher than the overall USAF airframe average, with the losses mainly attributed to operator error and equipment malfunctions.[222] The statistics may also imply a lower regard for flight safety in the drones' design, construction and operation, as compared to manned aircraft.

---

[219] Nick Hopkins, "Afghan civilians killed by RAF drone," *The Guardian,* 5 July, 2011, http://www.theguardian.com/uk/2011/jul/05/afghanistan-raf-drone-civilian-deaths.

[220] *Ibid.*

[221] Stuart Casey-Maslen, "Pandora's Box? Drone strikes under *jus ad bellum*, *jus in bello* and international human rights law," *International Review of the Red Cross* 94, No. 886 (Summer 2012): 597–626. http://www.icrc.org/eng/resources/international-review/review-886-new-technologies-warfare/review-886-all.pdf, 613.

[222] Brendan McGarry, "Drones Most Accident-Prone U.S. Air Force Craft: BGOV Barometer," *Bloomberg Government*, 18 June, 2012, http://www.bloomberg.com/news/2012-06-18/drones-most-accident-prone-u-s-air-force-craft-bgov-barometer.html.

Robotic military systems can also be vulnerable to attack by electronic countermeasures. In May of 2012, a Schiebel Camcopter S-100 drone crashed during a demonstration flight in South Korea, killing one person and injuring two others; the cause of the crash was indirectly linked to Global Positioning System jamming of local airports by North Korea.[223]

Modern automated technology is also susceptible to hacking.[224] Computer viruses might be introduced intentionally or unintentionally through a variety of vectors. Military systems with software are susceptible to the hacker threat, as demonstrated in 2009 Conficker virus attacks against Royal Navy, RAF and French Navy units, which disrupted British military communications and grounded the French Navy's entire Rafale fighter fleet.[225] In 2011, computers in the Predator drone cockpits at the USAF's Creech Air Force Base were compromised by a keystroke-logging virus; the virus did not affect Predator flying operations, but it demonstrated the robots' vulnerability to cyber attack.[226] These incidents illustrate the possibility that LARs could be hacked or infected with a virus, like any other device with software. Compromised in such a manner, they might be

---

[223] Chris Pocock, "UAV Crash in Korea Linked To GPS Jamming," *AINonline*, 1 June, 2012, http://www.ainonline.com/aviation-news/ain-defense-perspective/2012-06-01/uav-crash-korea-linked-gps-jamming.

[224] Lin, *Robot Ethics…,* 8.

[225] Kim Willsher, "French fighter planes grounded by computer virus," *The Telegraph*, 7 February, 2009, http://www.telegraph.co.uk/news/worldnews/europe/france/4547649/French-fighter-planes-grounded-by-computer-virus.html.

[226] Lolita C. Baldor, "Report: Computer Virus hits US Air Force drone program; Pentagon mum on impact," *The Canadian Press*, 8 October, 2011. http://search.ebscohost.com/login.aspx?direct=true&db=n5h&AN=MYO362981344411&site=ehost-live.

captured and re-programmed to turn on non-combatant or friendly forces.[227] In an increasingly computerized and networked world, such a potential loss of control may be sufficient grounds for not employing LARs in battle.

Holley's description of doctrine above states that doctrine evolves as a function of experience. Robotic system designs can also be improved with experience, as implied by the introduction of MAARS after experience gained with TALON SWORDS, as discussed above. Other examples of evolving robotic system designs include the Aegis and Phalanx CIWS systems. Phalanx system design has evolved through at least four major upgrades since it was first introduced, incorporating improved reliability, more operating modes, improved weapon and sensor performance and a self-testing mode.[228] The Aegis system has been through several hardware and software upgrades aimed at improving system performance and adding new capabilities.[229] A recent upgrade to Aegis in a small number of U.S. Navy ships left them with track-management problems that increased operator intervention to unacceptable levels and decreased the ships' ability to automatically share data with other ships via data link; this problem was overcome with a new baseline release.[230] In short, military robotic systems have indeed evolved with experience.

---

[227] Lin, Bekey and Abney, "Autonomous Military Robotics …, 2.

[228] Friedman, *The Naval Institute Guide* …, 495–496.

[229] Ewing *et al.*, *IHS Jane's C4ISR* …, 108–109.

[230] Christopher P. Cavas, "U.S. Navy Finds New Ways To Improve Aegis," *Defence News*, 7 April, 2013, http://www.defensenews.com/article/20130407/DEFREG02/304070006/U-S-Navy-Finds-New-Ways-Improve-Aegis.

Hardware and software failures might be overcome in the long term by acquisition of equipment that is more accurate and reliable. However, as demonstrated by examples presented in this chapter, in the short to medium term, robotic weapons systems operators may be more likely to demonstrate less trust in their equipment, and make conservative changes to operating doctrine to supervise their systems more closely.

Holley implies that doctrine for untried systems may be extrapolated from current knowledge and experience.[231] LAR doctrine may then be informed in part by lessons from the above accidents and mishaps, which demonstrate that robotic systems can be susceptible to equipment failure; they can have interoperability problems; a human in the loop can operate them incorrectly; they will act on the targeting data provided, even if that data is later found to be incorrect; they can be vulnerable to accidental or deliberate electronic deception such as IFF code changes or jamming; they are vulnerable to software viruses; and finally, an initially high accident rate may be expected. Unless technology improves to the point where all these problems are overcome, we may expect similar issues with LARs.

[231] Holley, "The Role of Doctrine," 2.

# CHAPTER SEVEN

## NO LARS IN OUR TIME?

> *The Human Rights Council should call on all States to declare and implement national moratoria on … LARs until such time as an internationally agreed upon framework on the future of LARs has been established.*
>
> – Christof Heyns, U.N. Special Rapporteur on Extrajudicial, Summary or Arbitrary Executions, U.N. report A/HRC/23/47, 9 April, 2013.

Military robotics accidents and mishaps such as those described in the previous chapter can have an impact on public perception of LARs. This was apparent to Lin, Bekey and Abney in their report to ONR, which stated:

> More than theoretical problems, military robotics have already failed on the battlefield, creating concerns with their deployment (and perhaps even more concern for more advanced, complicated systems) that ought to be addressed before speculation, incomplete information, and hype fill the gap in public dialogue.[232]

Unsurprisingly then, open source information about such failures and robotic weapon employment doctrine has generated much debate on LAR employment, perhaps abetted by the frame of reference of popular culture influences discussed earlier. Much of the debate has centred around discrimination, proportionality, military necessity and responsibility, as this chapter will demonstrate.

Three decades ago, at approximately the same time as movie theatre audiences first thrilled to James Cameron's *The Terminator*, the challenges of enabling LARs to discriminate between combatants and non-combatants were being discussed amongst the

---

[232] Lin, Bekey and Abney, "Autonomous Military Robotics …," 7.

research community.[233] A need to ensure that unmanned combat aerial vehicles complied with the LOAC and ROE was recognized in 2002, a year after the first successful test of an armed Predator drone.[234] By 2005, speculation about LARs promoting military adventurism in the future was appearing in the media.[235]

A new American government roadmap for military UAV development was also released that year.[236] The *Unmanned Systems Roadmap: 2005 – 2030* was the first such roadmap to discuss autonomous weapons employment, previous versions having limited their discussion of autonomy to UAV movement and navigation.[237] Broad contemporary discussion within western militaries included speculation on LARs impersonalizing war, making it more attractive and trumpeting their greater endurance and accuracy, while also reducing or removing the negative incentive of friendly casualties, legal constraints on LAR use, and responsibility for their decisions.[238]

---

[233] Cameron, Hurd and Wisher, *The Terminator*; see also note 156.

[234] Lazarski, "Legal Implications, 76.

[235] n.a., "Robotic warfare drawing nearer," *Washington Times.*

[236] Previous UAV roadmaps are available at Secretary of Defense, "Unmanned Aerial Vehicles Roadmap: 2000 – 2025," April 2001, http://www.hsdl.org/?view&did=705358; and, Secretary of Defense, "Unmanned Aerial Vehicles Roadmap: 2002 – 2027," December 2002, http://www.nasa.gov/centers/dryden/pdf/111759main_DoD_UAV_Roadmap_2003.pdf.

[237] Secretary of Defense, "Unmanned Aircraft Systems Roadmap: 2005 - 2030," A-2, A-4–A-6; and note 236, generally.

[238] See Cowan, "A theoretical, legal and ethical impact …," 6–8; Goldsmith, "Robots in the Battlespace…," 4–5; Mike Guetlein, "Lethal Autonomous Weapons – Ethical and Doctrinal Implications," Joint Military Operations Paper, United States Naval War College, 14 February 2005, www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA464896, 8–9; and Makin, "Future warfare or folly? …," 27, 35–37.

In a 2007 article for the *Armed Forces Journal*, U.S. Army Major Daniel L. Davis decries robots' lack of intuition, initiative, flexibility in following orders, quality of mercy and compassion.[239] Robots may be able to execute orders Terminator-like and bereft of human frailties as implied in Chapter 5's epigraph, but they would also then lack the emotions and empathetic tools to act humanely in the decidedly inhumane environment of the battlefield.[240] As Davis puts it, "[t]here are times when the circumstances of battle require pitiless brutality and the application of maximum violence. But there are other times, even while being shot at, when the best course of action is to hold fire."[241]

Moshkina and Arkin polled robotics experts, military members and policymakers as well as people in the general public on their impressions of what was possible and acceptable in military robotics in a 2008 survey for the U.S. Army.[242] Most of 430 survey respondents opposed the use of robots in direct combat, but supported their employment in reconnaissance roles; the survey also found that lethal actions by robots were unacceptable to most participants, and support for robotic combatants decreased as the degree of human control decreased.[243] It is clear that LARs were generally not

---

[239] Daniel L. Davis, "Who decides: Man or machine?" *Armed Forces Journal*, 1 November, 2007, http://www.armedforcesjournal.com/who-decides-man-or-machine/.

[240] *Ibid*..

[241] *Ibid*..

[242] See generally Moshkina and Arkin, "Lethality and Autonomous Systems ….."

[243] *Ibid.*, 5, 27, 41.

supported by those surveyed. Of note, survey respondents held the military chain of command most responsible for lethal mistakes by LARs.[244]

That same year, Lin, Bekey and Abney's report for ONR argued that robots' manufacturers may be held legally accountable for their robots' failures or wrongdoing—in whole or in part—as is the case in civil law, and also presented the notion of LARs being agents of their owners, that is, the chain of command that employs them.[245] This is reflected in current Canadian naval regulations: responsibility for weapons employment in the RCN is vested in the Commanding Officer (CO) of a ship by Maritime Command Order 4-15, which also allows the CO to delegate that responsibility to a small number of officers under his command.[246] Therefore, if we assume that a lethal error committed by a LAR can not be traced to an issue of product liability—say, for example, a software defect known to the LAR's manufacturer which is left uncorrected without warning the military user—and procurement or acceptance trials issues are not factors,[247] then the CO or delegated officer of a unit employing a LAR which commits a lethal error may be held accountable for that error.

The ONR report also echoes concerns about LAR susceptibility to hacking, as well as reduced casualties prompting an easier decision to go to war, as discussed earlier

---

[244] *Ibid.*, 18.

[245] Lin, Bekey and Abney, "Autonomous Military Robotics …," 56–60.

[246] Royal Canadian Navy, Maritime Command Order 04-15, "Command, Charge and Control of HMC Ships." February 2008, 2.

[247] Lin, Bekey and Abney, "Autonomous Military Robotics …," 73–74.

in this paper.[248] Sharkey makes the latter point bluntly, in a paper for the IEEE Computer Society: "[h]aving robots to reduce the 'body-bag count' could mean fewer disincentives to start wars."[249]

Researching LAR ethical behaviour, Arkin implemented the ethical governor discussed in chapter 5 in prototype form.[250] One of his prototype's ethical constraints forbids attacking cultural property in order to observe discrimination, however it assumes that cultural properties will be clearly marked as such by the enemy; another constraint caters to military necessity by obliging a proportionally appropriate attack against a clearly identified enemy tank inside a defined targeting zone.[251] While these ethical constraints appear sound, their effective application by Arkin's governor seems to presume that either the enemy will cooperate in clearly identifying its cultural landmarks and tanks, or that LAR sensors and data fusion algorithms will be effective enough to discriminate targets without the assistance of identifying markings. The former presumption may be questionable in view of Sharkey's doubts about LARS' ability to discriminate and Dorn's concern for abuse of cultural markings discussed earlier. Additionally, the Aegis and Patriot examples cited in the previous chapter suggest that absolute faith in sensor and data fusion effectiveness may not be justified. The governor model also employs an algorithm which optimally estimates a proportional response to

---

[248] *Ibid.*, 2.

[249] Noel Sharkey, "Cassandra or false prophet of doom: AI robots and war," *IEEE Intelligent Systems* 23, No. 4 (July 1, 2008): 14–17, 16.

[250] See generally Arkin, *Governing Lethal Behavior*…, 177–209.

[251] *Ibid.*, 179, 181.

the situation sensed by the robot, with the aim of defeating the target with minimal collateral damage, guided by programmed military necessity parameters; again, Arkin's test scenarios seem to assume completely effective sensors.[252]

The model contains another design feature which questions the effectiveness—or trust placed in the effectiveness—of autonomous targeting engines: a responsibility advisor, whose function is to ensure a LAR properly assesses targets with respect to military necessity, discrimination and proportionality, and verifies its operator's legal authority to task it; but the advisor includes an operator override which permits an operator to veto weapons firing in real time.[253] An operator override may suggest a lack of confidence in LARs' ability to act as effective ethical agents: Arkin himself acknowledges that a LAR's operator may have better ethical situational awareness than LARs themselves.[254]

As a final comment on Arkin's ethical governor, he acknowledged that the prototype was "incomplete, fraught with assumptions, and only weakly tested."[255] Combined with a presumption of perfect sensor effectiveness and inclusion of an operator override, it may be inferred that development of an ethical LAR is unlikely in the foreseeable future.

---

[252] *Ibid.*, 185–188.

[253] *Ibid.*, 125, 145–147, 196–197, 202–203, 205–207.

[254] *Ibid.*, 207.

[255] *Ibid.*, 177.

As discussed earlier, not all researchers in related fields agree on the development and employment of LARs. An international non-governmental organization named the International Committee for Robots Arms Control (ICRAC) formed in 2009 in response to its members concerns about rapid military robotics development.[256] Its twenty-six members from a range of disciplines related to military robotics issued a statement the following year describing LARS as potentially destabilizing, and highlighting concerns about discrimination, proportionality and responsibility for war crimes in particular.[257] Among points not specifically related to LARs, they called for a prohibition against lethal autonomous robots, and human accountability for any decision of a robotic weapons system to use force.[258]

The military robotics debate subsequently captured the attention of Philip Alston, the U.N. Special Rapporteur on Extrajudicial, Summary or Arbitrary Executions. His 2010 *Interim report of the Special Rapporteur on extrajudicial, summary or arbitrary executions* [*sic*] acknowledged that unmanned systems could potentially save military and civilian lives; however, he expressed concern that lethal robotics with decreasing human control had received little attention from the human rights community up to that point, alluding to science fiction as he did so.[259] He saw advantages to the use of robots, hypothesizing that their superior endurance and lack of emotion could reduce the

---

[256] International Committee for Robot Arms Control, "Home."

[257] International Committee for Robot Arms Control, "Who we are," last accessed 14 June, 2014, http://icrac.net/who//; and, International Committee for Robot Arms Control, "Statements," last accessed 14 June, 2014, http://icrac net/statements/.

[258] International Committee for Robot Arms Control, "Statements."

[259] General Assembly, A/65/321, 10–11, 16.

resulting harm they do compared to humans, and that military robots might aid military transparency and accountability by recording their surroundings.[260]

Alston called upon the human rights and international communities "to address the legal, political, ethical and moral implications of the development of lethal robotic technologies,"[261] citing concerns including responsibility for harm done by robots, standards ensuring compliance with IHL and human rights, a lack of sympathy, remorse or empathy in robots, and the proportionality issues discussed earlier in this paper.[262] His report concludes with recommendations for onboard recording systems, safety standards at least as good as those applied to manned systems, and pre-deployment testing requirements.[263]

Subsequently, in a paper for the *Journal of Military Ethics*, Sharkey expressed scepticism over the possibility of LARs exhibiting aspects of human intelligence and stated that current and emerging robots would be unable to make decisions catering to *jus in bello*'*s* principles of discrimination or proportionality.[264] That is to say that a computer faced with what one might consider a straightforward order to not shoot civilians must be able to distinguish civilians from combatants—who might be concealing their identity—

---

[260] *Ibid.*, 16.

[261] *Ibid.*, 11.

[262] *Ibid.*, 17–20.

[263] *Ibid.*, 21–22.

[264] Noel Sharkey, "Saying 'No!' to Lethal Autonomous Targeting," *Journal of Military Ethics* 9, No. 4, (2010): 369–383, http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=56042208&site=ehost-live, 378.

using available sensors,[265] a seemingly impossible task when one considers Sharkey's observation that "British teenagers beat surveillance cameras just by wearing hooded jackets."[266]

Describing the principle of proportionality, the U.S. Army's Field Manual 3-24, *Insurgencies and Countering Insurgencies,* states "[t]he anticipated injury or damage caused to civilians or civilian property must not be excessive in relation to the concrete and direct military advantage anticipated by an attack on a military objective."[267] LARs' computers may be able to tally and compare casualty and property damage statistics, but ultimately a judgement call about the proportionality of an attack would have to be made based on the circumstances at hand, along with the certain knowledge of punishment if a bad decision is made.[268] Lacking compassion and other emotional qualities discussed earlier, how could a robot exercise that judgement? It could not be punished for making a wrong decision: as Sharkey states, "[w]e could threaten to switch it off but that would be like telling your washing machine that if it does not remove stains properly you will break its door off."[269] As discussed earlier, in the absence of product liability issues, an officer who decided to use LARs in such circumstances could be held accountable.

---

[265] Ibid., 379.

[266] Ibid., 379.

[267] United States Army, FM 3-24/MCWP 3-33.5, *Insurgencies and Countering Insurgencies*, 2 June, 2014, http://armypubs.army.mil/doctrine/DR_pubs/dr_a/pdf/fm3_24.pdf, 9-12.

[268] Sharkey, "Saying 'No!' …," 380–381.

[269] *Ibid.*, 380.

The United Kingdom Ministry of Defence published *Joint Doctrine Note 2/11 – The UK Approach to Unmanned Aircraft Systems* in 2012. The document, which notes the confusion in robotics jargon discussed earlier,[270] insists that autonomous systems "must be capable of achieving the same level of situational understanding as a human."[271] The doctrine note recognizes the need for effective discrimination and proportionality in unmanned systems, and argues that the use of automatic modes of operation is a military necessity in a defensive scenario where human reaction time is insufficient.[272] It outlines the British position on LAR employment as follows:

> Meeting the requirement for proportionality and distinction would be particularly problematic, as both of these areas are likely to contain elements of ambiguity requiring sophisticated judgement. Such problems are particularly difficult for a machine to solve ... Until such a capability is achieved it is likely that, apart from some niche tasks, human intervention will continue to be required at key stages of an unmanned aircraft's mission if it involves weapon-delivery.[273]

The UK doctrine note also calls for clear accountability for LAR actions, citing LARs' inability to rationalize or justify their actions as an additional problem, despite an ability to efficiently engage an identified target.[274]

A paper released by HRW and the Harvard Law School that same year entitled *Losing Humanity: The Case against Killer Robots* cited fears of increasing robotic

---

[270] UK MoD Joint Doctrine Note 2/11, 2-2–2-3.

[271] *Ibid.*, 2-3.

[272] *Ibid.*, 5-2.

[273] *Ibid.*, 5-4.

[274] *Ibid.*, 5-11.

weapons autonomy, and implored states to conduct impact assessments of LARs in accordance with Article 36 of Additional Protocol I to the Geneva Conventions.[275] LARs' lack of human judgement and emotion—described as necessary for the protection of civilians—and unclear accountability for LAR war crimes is also discussed.[276] They also argue that LARs may be unacceptable under the Martens Clause due to many stakeholders' strong negative opinions of their use.[277] HRW recommended that states "[p]rohibit the development, production, and use of fully autonomous weapons."[278]

Besides presenting material on LARs in its *International Review* issue mentioned earlier, like other interested parties the ICRC questions LARs' ability to address distinction, proportionality and military necessity, and responsibility; it also alludes to the Martens Clause discussed earlier.[279] The ICRC does not call for a ban on LARs, but in an address to the 2014 Conventional Weapons Convention in Geneva it stated "[t]here is a sense of deep discomfort with the idea of any weapon system that places the use of force beyond human control."[280] The ICRC's view on LAR development may be best summarized by a statement in its commentary on Article 36 of Additional Protocol I to

---

[275] Human Rights Watch and Harvard Law School International Human Rights Clinic, "Losing Humanity …," 3, 6–7, 21; and United Nations, Protocol Additional to the Geneva Conventions of 12 August 1949 …, 21.

[276] Human Rights Watch and Harvard Law School International Human Rights Clinic, "Losing Humanity …," 4, 30–35.

[277] *Ibid.*, 35.

[278] *Ibid.*, 5.

[279] International Committee of the Red Cross, Resource Centre, "Autonomous weapons: ICRC addresses meeting of experts," last updated 5 June, 2014, http://www.icrc.org/eng/resources/documents/statement/2014/05-13-autonomous-weapons-statement htm.

[280] *Ibid.*.

the Geneva Conventions: “all predictions agree that if man does not master technology, but allows it to master him, he will be destroyed by technology.”[281]

A second U.N. report followed in 2013, entitled *Report of the Special Rapporteur on extrajudicial, summary or arbitrary executions, Christof Heyns*, which summarized much of the earlier debate.[282] In his report, Heyns contended that LARs will further distance humans from targeting decisions.[283] Acknowledging that LARs have not been developed yet, he argued for a proactive ban on LARs in order to avoid a situation where technology overtakes its own responsible regulation.[284] Among other concerns, he discusses potential for LAR-instigated asymmetric warfare, proliferation of unregulated LARs to states and non-state actors, and the legal requirement for a human in command.[285] Heyns concluded with a number of recommendations including the ban forming the epigraph to this chapter, reaffirmation of IHL by states, and establishment of norms of conduct and ethics for LARs.[286]

The previously-mentioned Campaign to Stop Killer Robots (CSKR) boasts a membership list that includes HRW, the ICRAC, Amnesty International, Mines Action

---

[281] International Committee of the Red Cross, Protocol Additional to the Geneva Conventions of 12 August 1949, and relating to the Protection of Victims of International Armed Conflicts (Protocol I), 8 June 1977, “Commentary – New weapons,” last accessed 13 June, 2014. http://www.icrc.org/applic/ihl/ihl nsf/1a13044f3bbb5b8ec12563fb0066f226/f095453e41336b76c12563cd00432aa1.

[282] See generally, General Assembly, A/HRC/23/47.

[283] *Ibid.*, 5.

[284] *Ibid.*, 7, 9–10.

[285] *Ibid.*, 16.

[286] *Ibid.*, 21–22.

Canada and numerous other non-governmental organizations.[287] CSKR maintains that machines should not be allowed to exercise the power of life or death in conflict, and military robots require human control on humanitarian and legal grounds.[288] It cites concerns over a potential LAR arms race between high-technology powers, as well as the familiar discrimination, proportionality and responsibility issues raised earlier.[289] Supporting Heyns' recommendation for a ban of LARs, and LAR discussions which followed at the Conventional Weapons Convention, CSKR called for an international treaty and national laws to enact Heyns' recommended ban.[290] CSKR continues to actively support Heyns' report a year after its release: in his recent *Ottawa Citizen* editorial discussed earlier in this paper, ICRAC and CSKR member Ian Kerr succinctly summarized the ethical and moral debate over killer robots as a question of *relinquishment*; that is, voluntarily giving machines control of life or death decisions.[291]

The public debate over LARs demonstrates general consensus on the need for LARS to respect the principles of discrimination, proportionality, military necessity and responsibility for war crimes. Clearly, proponents of future technology such as Arkin are confident that such compliance is possible. However, the current state of the art and past experience suggests otherwise, leading many stakeholders to oppose LARs.

---

[287] Campaign to Stop Killer Robots, "Who we are."

[288] Campaign to Stop Killer Robots, "The Solution," last accessed 14 June, 2014, http://stopkillerrobots.org/the-solution/.

[289] Campaign to Stop Killer Robots, "The Problem," last accessed 14 June, 2014, http://stopkillerrobots.org/the-problem/.

[290] Campaign to Stop Killer Robots, "The Solution."

[291] Kerr, "Keep killer robots fictional."

The debate appears to be affecting the military community. NATO's 2012 *Guidance for developing Maritime Unmanned Systems (MUS) capability* states "it [is] rational to conceive scenarios where UUVs sense, track, identify and destroy targets autonomously;"[292] however, the most recent U.S. roadmap—*Unmanned Systems Integrated Roadmap FY 2013 – 2038*—contains no references to LARs.[293] Dismissing the NATO statement as speculative, it might be assumed that U.S. military stakeholders have abandoned plans to field LARs, at least until the required technologies mature to the point where machines may be trusted with life or death decisions.[294] Further, a 2012 U.S. Department of Defence Directive entitled *Autonomy in Weapon Systems* clearly states that "[a]utonomous … weapon systems shall be designed to allow commanders and operators to exercise appropriate levels of human judgment over the use of force."[295] The directive requires compliance with the LOAC, applicable treaties, ROE and weapons safety doctrine; demands procedures allowing human operators to activate or deactivate the systems; and forbids the selection of human targets by LARs.[296] Clearly, U.S. LAR policy has not ignored the debate.

As a final point in the discussion of the public debate over LARs—which has involved states, international organizations, major non-governmental organizations,

---

[292] North Atlantic Treaty Organization, *Guidance for developing Maritime Unmanned Systems…*, 7.

[293] Department of Defense, 14-S-0553, *Unmanned Systems Integrated Roadmap FY 2013–2038*.

[294] It is also possible that a more permissive approach is taken towards MUS LAR employment, as the underwater warfare environment does not have non-combatants in it and is therefore seen as a low-risk operating environment for LARS.

[295] Department of Defense Directive 3000.09, *Autonomy in Weapons Systems* (Washington: Deputy Secretary of Defense, 21 November, 2012), http://www.dtic.mil/whs/directives/corres/pdf/300009p.pdf, 2.

[296] *Ibid.*, 3.

special interest groups and academics of various stripes—recall chapter 4's discussion of the influence of popular culture. A spontaneous internet search on the keywords *Christof Heyns* and *Terminator* yields approximately 6,800 results.[297] Whether those results contain facts and reasoned opinions or uninformed conjecture, they may illustrate that popular culture has infected the public conscience with concern about LARs.

The general acceptance by states, international organizations, academics and militaries of both the need for and the perceived inability of LARs to operate within IHL's constraints and restraints lend credence to the various calls for bans or limits on their use, as well as the recent policy responses by the U.S. discussed above. As implied in the discussion of Arkin's ethical governor, the current state of technology does not allow machines to effectively address discrimination, proportionality and military necessity, and inclusion of an operator override reinforces the point that a human must still be responsible for lethal force exerted by a robot. Given the accidents and mishaps described in the previous chapter and the resulting broad debate over prospects of handing lethal power over to machines at some point in the future, the public conscience is right to be clearly concerned about killer robots.

---

[297] The author conducted an impromptu search on the keywords "Christof Heyns" and "Terminator" using the Google search engine on 10 June, 2014, and obtained 6,780 results.

# CHAPTER EIGHT

## NO MAN'S LAND, OR MAN ON THE LOOP?

This chapter will present courses of action that may be followed to mitigate the problems posed by LAR employment. It will examine and compare those courses of action with respect to the *jus in bello* principles of discrimination, proportionality and military necessity as well as the legal requirement for responsibility, drawing on previous chapters.

The moratoria on LARs proposed by Christof Heyns did not include their development, but it did recommend banning their testing and employment.[298] In a contemporary essay for the Stanford University Hoover Institute's *Policy Review*, Kenneth Anderson and Matthew Waxman argued that banning LARs might stunt the development of more accurate and effective military robotic systems, potentially denying future improvements in discrimination and proportionality.[299] The following discussion will assume that no such ban will take place.

Recalling the earlier discussion of mine danger areas, Armin Krishnan notes a similarity between LAR employment and mine warfare in his book *Killer Robots: Legality and Ethicality of Autonomous Weapons*, pointing out that some sea mines and

---

[298] General Assembly, A/HRC/23/47, 21.

[299] Kenneth Anderson and Matthew Waxman, "Law and Ethics for Autonomous Weapon Systems: Why a Ban Won't Work and How the Laws of War Can," Stanford University Hoover Institution National Security and Law Essay, 9 April, 2013, http://www.hoover.org/research/law-and-ethics-autonomous-weapon-systems-why-ban-wont-work-and-how-laws-war-can, 1–2.

anti-tank mines are legal due to a limited ability to discriminate.[300] Thurnher cites the Korean demilitarized zone as a modern example of a warning zone, which serves proportionality through a low risk of collateral damage.[301] Krishnan suggests that LARs could likewise be employed in marked and recorded zones only.[302] This would be a feasible solution were it possible for humans and robots to not mix,[303] perhaps through the implementation of ROZs for LAR operations. However, as Cowan states, "[t]he problem with this logic is that the French General Staff said the same thing in 1939 concerning tanks and aircraft."[304] Necessary de-confliction of friendly human combatants and LARs could presumably be handled in the same manner as the PMI and airspace or waterspace management doctrines discussed earlier, with a *LARspace* doctrine establishing LAR operation areas for civilians and friendly combatants to avoid.

Such an exclusion zone model, which excludes non-combatants from zones inhabited by LARs, would serve the *jus in bello* principles of distinction, proportionality and military necessity well when LARs are operating in unambiguous circumstances as discussed earlier, if certain critical assumptions are satisfied. If it may be accurately assumed that the zone was declared and marked adequately; if people comply with

---

[300] Armin Krishnan, *Killer Robots: Legality and Ethicality of Autonomous Weapons* (Farnham: Ashgate Publishing, 2009), Kindle Edition, 162.

[301] Thurnher, "No one at the controls …," 83.

[302] Krishnan, *Killer Robots* …, 162.

[303] Alexander Knott, "C2 in Robotic Warfare," briefing slides with scripted commentary, Carlisle Barracks, U.S. Army War College, Joint Robotics Course CC2213, April 2006, quoted in Cowan, "A theoretical, legal and ethical impact …," 10.

[304] Cowan, "A theoretical, legal and ethical impact …," 10.

warning markings, such that only combatants are inside the zone and accidental or overzealous targeting can not occur; if friendly combatants are easily discriminated; if enemy forces *hors de combat* are also readily identifiable; and finally, if any of those four assumptions fail, the LARs' targeting abilities may somehow be neutralized;[305] then LAR operation inside exclusion zones might be feasible doctrine.

However, the number of assumptions underpinning that doctrine, combined with the lack of faith in technology being equal to the task expressed earlier in this paper, cast doubt upon its effectiveness in complex situations. Given that fatal accidents and mishaps such as those presented earlier in this paper can rapidly enter the public conscience, LAR ROZs and LARspace doctrine should be limited to low-risk situations where automatic target selection may be performed in what Marcello Guarini and Paul Bello refer to as "the classical theater:"[306] an area containing little other than enemy platforms or machines as targets, or well-discriminated friendly forces.[307] U.S. Department of Defence Directive (DoDD) 3000.09 *Autonomy in Weapon Systems* supports this policy by permitting the use of LARS—under human supervision—against non-human targets, when defending manned posts or platforms against high speed or multi-threat attacks.[308]

---

[305] Krishnan, *Killer Robots* …, 163.

[306] Marcello Guarini and Paul Bello, "Robotic Warfare: Some Challenges in Moving from Noncivilian to Civilian Theaters," chap. 8 in *Robot Ethics* …, 130.

[307] *Ibid*., 130; and Anderson and Waxman, "Law and Ethics for Autonomous Weapon Systems …," 6.

[308] Department of Defense Directive 3000.09, *Autonomy in Weapons Systems*, 3.

That directive mirrors the U.S. Army's re-purposing of its TALON SWORDS armed telerobots in Afghanistan as stationary defensive platforms discussed earlier.[309]

The above requirement for human supervision speaks to human involvement in a robotic system's actions. Sharkey points out that autonomy does not have to be absolute, stating that there is room for some human involvement in LAR operation.[310] The varying degrees of autonomy possible in robotic systems may be categorized in a number of ways,[311] but if autonomy is characterized as a function of human supervisory interaction within a robotic system's OODA loop, then humans may be said to be in, on, or out of the loop.[312]

*Human in the loop* systems such as the Gunar/Mk 69 Gun Fire Control System—a surface and anti-aircraft direction system discussed in chapter six—fire only on human command, since human operators must close electrical switches to enable firing.[313] *Human on the loop* (HOTL) systems such as the RCN's SHINPADS combat management system can fire a ship's anti-aircraft weapons automatically, but have a means of human override through their veto switches.[314] *Human out of the loop* systems

---

[309] See note 217.

[310] Sharkey, "Saying 'No!' …," 377.

[311] *Ibid.*, 377, describes how U.S. military services use models describing three, four and ten levels of autonomy; other conceptual approaches use four, five, eight or eleven levels, as discussed in NIST Special Publication 100-II-1.0, *Autonomy levels for Unmanned Systems (ALFUS) Framework – Volume II: Framework Models,* ed. Hui-Min Huang, December 2007, http://www.nist.gov/customcf/get_pdf.cfm?pub_id=823618, 48–49.

[312] Human Rights Watch and Harvard Law School International Human Rights Clinic, "Losing Humanity …," 2.

[313] See note 202.

are fully autonomous, acting without human involvement.[315] But this method of categorizing autonomy is not absolute: the Gunar/Mk 69 system may also be considered an HOTL system, since firing is semi-automatic: firing continues until an operator acts on a conscious choice to release a key, inhibiting the firing circuit.[316] Borgeit describes a similar scenario where a human is effectively "a 'kill switch,' providing weapons-release ability, terminating a mission, or ordering the vehicle to depart the battle space."[317]

Since semi-automatic and automatic-capable robotic weapons systems with an HOTL such as SHINPADS and Aegis have been employed for several years—notwithstanding the serious and fatal accidents and mishaps discussed earlier—it follows that a similar approach may be taken to governing LARs. Anderson and Waxman support this by stating that LARs "might be set with the human being not required to give an affirmative command, but instead merely deciding whether to override and veto a machine-initiated attack."[318]

An HOTL would serve the principle of discrimination by helping to overcome LARs' sensor and contextual processing limitations in ambiguous circumstances. In complex operations such as counter-insurgent operations, detecting the nuances that discriminate combatant from non-combatant is difficult and robots will likely be unable

---

[314] See notes 46, 47 and 203.

[315] Human Rights Watch and Harvard Law School International Human Rights Clinic, "Losing Humanity …," 2.

[316] See note 202.

[317] Borgeit, "Eliminating the 'You' …."

[318] Anderson and Waxman, "Law and Ethics for Autonomous Weapon Systems …," 7.

to do it in the foreseeable future.[319] In the book *Human-Robot Interactions in Future Military Operations*, Michael J. Barnes and William Evans III state "[i]t will be crucial to have software 'brakes' to ensure that robotic decisions that make tactical sense do not have unintended consequences resulting in either unsafe or unethical acts."[320]

With respect to proportionality, LARs' computational speed and accuracy could make them capable of precision strike, reducing the likelihood of collateral damage in the same manner that precision-guided munitions did during the 1991 Gulf War.[321] None the less, proportionality—and, by extension, military necessity—may be reinforced by an HOTL when considering the lack of trust in a robot's ability to assess proportional responses discussed earlier in this paper, particularly the operator override built into Arkin's ethical governor. While detailed constraints and restraints on LARs' use of force such as those specified by DoDD 3000.09 above impose clear limits on the use of force, inclusion of an HOTL would provide some measure of failsafe assurance, should the sensory and contextual limitations discussed above manifest during targeting or weapon selection. It also provides an improved link to command responsibility for LARs' actions since a human operator is involved in the actions of the robot.

---

[319] Miller, "Smart enough to kill?," 14; and Michael J. Barnes and William Evans III, "Soldier-Robot Teams in Future Battlefields: An Overview," chap. 2 in *Human-Robot Interactions in Future Military Operations*, ed. by Michael Barnes and Florian Jentsch (Farnham: Ashgate Publishing, 2009), Kindle Edition, 23.

[320] Barnes and Evans, "Soldier-Robot Teams …," 23.

[321] Guetlein, "Lethal Autonomous Weapons …," 5. The United States employed precision guided munitions (PGM) against specific target sets during the 1991 Gulf War in order to address proportionality concerns, according to Michael W. Lewis, "The Law of Aerial Bombardment in the 1991 Gulf War," *American Journal of International Law* 97, no. 3 (July, 2003): 481-509, http://www.jstor.org/stable/3109837, 491–494, 496, 502. While a PGM attack against one target resulted in the tragic deaths of numerous civilians, this was not attributed to the PGM's accuracy or lack thereof.

Command responsibility is a key strength of being in or on the loop. In a paper for the United States Naval War College, Major Mike Guetlein states "the military has a strong history and culture of requiring MITL [men in the loop] and demanding accountability."[322] He also points out that "[w]hen something goes wrong, society wants to know who is responsible. In the military, responsibility always falls to the commander."[323] A human in or on the loop with a LAR provides assurance that someone is involved in LARs' actions, whatever the outcome of those actions. Alston acknowledges that current unmanned systems such as Predator and Reaper have a man in the loop, leaving the chain of command in charge of the decision to use lethal force.[324]

The RCN's command and control policy supports this, since Maritime Command Orders clearly impart authority and responsibility for the use of a ship's weapons, sensors and tactical employment upon the ship's Commanding Officer without reference to the weapons' modes of operation.[325] The United Kingdom's UAV doctrine is more explicit, stating that "[l]egal responsibility for any military activity remains with the last person to issue the command authorising a specific activity … [and] the individual giving orders for [a system] … will ensure its continued lawful employment throughout any task."[326] While the latter example oversimplifies the assignment of responsibility by focusing on only one member of a chain of command, these examples demonstrate that a human on

---

[322] Guetlein, "Lethal Autonomous Weapons …," 8.

[323] *Ibid.*, 13.

[324] General Assembly, A/65/321, 13.

[325] See note 246.

[326] UK MoD Joint Doctrine Note 2/11, 5-5.

the loop would retain responsibility for the actions of robotic weaponry under his charge—whether that robot is a LAR or not—given clear orders to that effect.

Legal responsibility for LAR malfunctions may not be so clear-cut in cases which are not traceable to command decisions. Accidents or mishaps may be traced to manufacturing or programming errors, procurement problems or oversights during acceptance trials, or subordinate officers, as discussed earlier. Peter Asaro argues that such malfunctions may be dealt with legally in the same manner as similar problems with modern robots, which are covered by product liability law.[327] Examples of modern court cases alleging human injury by robots—attributed in part to product liability—include an industrial robot grabbing a man in a Swedish factory and more than seventy claims involving *da Vinci* surgical telerobots.[328] While the validity of such cases is a matter for courts to decide, legal mechanisms are clearly available to address cases where a human is harmed by a robot.

The HOTL model has a significant weakness: the perceived inability of humans to react to military threats quickly in an age of supersonic weaponry. The speed of modern warfare was an impetus for creating Aegis and SHINPADS to automate and speed up the detect-to-engage sequence.[329] However, the VINCENNES and Patriot incidents discussed earlier demonstrate that an HOTL may not process information or react fast

---

[327] Peter M. Asaro, "A Body to Kick, but Still No Soul to Damn: Legal Perspectives on Robotics," chap. 11 in *Robot Ethics*…, 170.

[328] See *The Local – Sweden's News in English*, "Robot attacked Swedish factory worker," last updated 28 April, 2009, http://www.thelocal.se/20090428/19120; and Alyssa E. Lambert, "More recalls, lawsuits for da Vinci surgical robots," *Trial*, 9 January, 2014, http://www.justice.org/cps/rde//justice/hs.xsl%20/22569.htm.

[329] See notes 44 and 47.

enough or accurately enough to employ LARs, in some circumstances. Sparrow suggests that the speed of automated combat may eventually surpass human ability to participate in it, making LARs a necessity.[330]

That said, advances in automation and weapons technology also assist humans in keeping up with the rapid tempo of modern war, as seen in the Aegis and CIWS system improvements discussed earlier in this paper. The Patriot missile system provides another example. After the friendly fire incidents discussed in chapter six, frequent technological improvements were made to Patriot, including an improved radar processor which allows target detection at longer ranges,[331] thereby increasing the available human reaction time in the missile system's detect-to-engage sequence. If such development eventually proves to be insufficient—that is, it does not prevent the speed of robotic systems from eventually overwhelming human ability, and LARspace doctrine can not be employed to overcome that HOTL weakness—then commanders finding themselves in situations that are at risk of developing too rapidly may be forced to make difficult and potentially costly choices after weighing military necessity against proportionality.

Other solutions to LAR employment are possible. Krishnan suggests that LAR use in civilian-populated areas could be prohibited by law,[332] allowing their use against material targets only. In a paper presented to the American Society of Naval Engineers,

---

[330] Sparrow, "Robotic Weapons …," 121–122.

[331] Faisal J. Abbas, "New radar system enhances Patriot missiles by up to 50 percent: Raytheon executive," *Al Arabiya News*, 21 February, 2013, http://english.alarabiya net/articles/2013/02/21/267603.html.

[332] Krishnan, *Killer Robots* …, 162.

John S. Canning refines such targeting restrictions further by proposing that LARs target weapons only, citing anti-tank mines as a contemporary example of a weapon targeted against a weapon.[333] While this solution would serve the principle of military necessity well by limiting targeting to valid non-human military objectives, it hinges on an assumption that sensors are accurate enough to discriminate effectively, something not yet achievable as discussed earlier. It also raises the possibility of collateral damage in the destruction of a weapon, unless LARs also have processing capability and targeting accuracy sufficient to disarm an opponent with minimal force, something Canning concedes is not yet possible.[334]

Examining the above LAR employment options, the LARspace/LAR ROZ model meets the requirements of just war theory in a manner similar to minefields and demilitarized zones. It is best-suited to unambiguous defensive scenarios where few non-combatant or friendly contacts are anticipated and there is therefore much room for error, such as underwater warfare or single-ship air defence.[335] The HOTL model meets the requirements of discrimination, proportionality and military necessity in more complex scenarios. It also provides for recourse to human control if there is sufficient reaction time, and clear responsibility for LARs' actions if things go wrong. At worst, a human on

---

[333] John S. Canning, "Weaponized Unmanned Systems: A Transformational Warfighting Opportunity, Government Roles in Making it Happen," in *Engineering the Total Ship (ETS) 2008 Proceedings* (Falls Church, VA: American Society of Naval Engineers, 23–25 September, 2008), https://www.navalengineers.org/SiteCollectionDocuments/2008%20Proceedings%20Documents/ETS%202008/Canning%20Weaponized%20Unmanned%20Systems%20-%20A%20Transformational%20Opportunity.pdf, 4–7.

[334] *Ibid*., 5–6.

[335] Thurnher, "No one at the controls …," 83; and Guarini and Bello, "Robotic Warfare …,"130.

the loop would maintain the current status quo in robotic weapon system control; since semi-automatic and automatic systems with an HOTL already exist, commanders and policymakers have doctrine and practical experience derived from operation of systems like the Phalanx CIWS, SHINPADS, Aegis and others to draw on, to ensure they comply with just war theory's *jus in bello* principles and the LOAC's requirement for command responsibility.

# CHAPTER NINE

# CONCLUSION

*Let us redefine progress to mean that just because we can do a thing, it does not necessarily follow that we must do that thing.*
– Federation President, *Star Trek VI: The Undiscovered Country,* 1991.

Modern advances in computer and robotics technology have allowed military forces to operate robotic weapons systems remotely and with increasing degrees of autonomy. It may only be a matter of time before society faces a revolution in military affairs brought about by autonomous robots.

Today, thanks in part to the influence of popular culture, lethal autonomous robots—the stuff of dystopian science fiction for over sixty years—are perceived to be close enough to reality that they have the attention of not just science fiction fans, scientists and technophiles, but also governments, their militaries, non-governmental organizations, and international organizations such as the U.N. itself. This paper has shown that the modern use of telerobots in combat, and projected research and development of unmanned weapons systems exemplified by successive U.S. government roadmaps discussed earlier, has drawn considerable public attention to the issue of LAR employment, particularly its ethical and legal dimensions.

That attention and the resulting debate have been complicated by broad and imprecise jargon used by stakeholders when discussing robotics in general and robot autonomy in particular. Robotics is a highly technical field, and discussions of autonomy may cover a broad spectrum of robotic self-control as discussed earlier. Therefore it is unsurprising that much of the debate on LARs incorporates popular culture references in order to appeal to the layperson.[336]

The public perception of robotic weaponry is a key element in the debate over LARs. That perception is abetted by popular culture, which frames high technology in a perspective understandable to an unscientific or non-technical audience. This is not necessarily a bad thing, since popular culture such as science fiction stories can inspire and predict the technology of tomorrow. This paper has presented examples of modern conveniences and military technology first introduced to the public through science fiction. But detractors may be quick to point out—quite rightly—that carpet bombing and atomic bombs were also introduced by science fiction.[337] Some solace may then be taken in science fiction authors' more fantastic killer robot predictions being wide of the mark: the *Terminator* franchise's Judgement Day passed without incident, and the Sentinels of *X-Men: Days of Future Past* recently invaded motion picture screens, but not real life.[338] Still, this paper has shown that literature on LARs is rife with alarmist references to fictional anthropomorphic killer robots, livening up and possibly skewing the debate.

Moving beyond science fiction, it can be seen that the potential advent of LARs raises serious questions about their employment within the principles of just war theory and the LOAC which are difficult to answer before the fact. Discrimination,

---

[336] The result of the earlier internet search linking fictional Terminators and the UN Special Rapporteur on extrajudicial, summary or arbitrary executions is a case in point.

[337] See notes 108 and 109.

[338] See Smith, "How close were the Terminator films to the reality of 2011?" and IMDb, "X-Men: Days of Future Past (2014)," last accessed 1 July, 2014, http://www.imdb.com/title/tt1877832/.

proportionality, military necessity and responsibility for LARs' actions are major areas of ethical and legal concern highlighted in the debate, based in part on past experiences with semi-automatic and automatic-capable robotic weapons systems, particularly accidents and mishaps such as the examples presented earlier in this paper.

The story of USS STARK illustrated the impact of robotic system malfunctions. Civilian deaths during an RAF Reaper strike showed how inadequate sensors can contribute to proportionality problems. The VINCENNES incident's tragic errors occurred due to fast-paced and context-free threat evaluation and weapons assignment based on bad data. Discrimination problems in a threat-intensive environment lead to friendly fatalities in Patriot operations during OPERATION IRAQI FREEDOM. Fears of robots running amok contributed to TALON SWORDS being restricted to static defence duties in Afghanistan. Finally, the exploitable nature of modern networked technology was highlighted by computer virus attacks against the USAF's Predator operations centre as well as British and French military forces. Any of these things—which involved varying levels of human interaction—may cause concern by itself; taken together, they paint an alarming picture if one takes the human out of the loop. Taken to an extreme, how would one stop an autonomous, malfunctioning, weakly-sighted, sensory-overloaded or hacked robot on a rampage?

This chapter's epigraph hails from a science fiction movie, but its sentiment is echoed by stakeholders who want to *keep* LARs firmly in the realm of science fiction.[339]

---

[339] See Leonard Nimoy *et al.*, "Space Battle," *Star Trek VI: The Undiscovered Country*, DVD, directed by Nicholas Meyer (1991; Hollywood: Paramount Home Video, 1998); and Kerr, "Keep killer robots fictional."

However, the predictive and inspirational nature of science fiction suggests that such sentiments are folly. Arkin succinctly states that “[t]he trend is clear: [w]arfare will continue and autonomous robots will ultimately be deployed in its conduct.”[340]

One thing is certain: experience gained with modern military robotic systems, and the ongoing public debate among many stakeholders that has followed it, has influenced the policies of states in the matter of lethal autonomous robots. This is clear from U.K. and U.S. restrictions on LARs, as well as the absence of LARs from the most recent U.S. roadmap, as discussed earlier. The groundswell of opposition to LARs in recent years and government policy responses to it suggests that LARs will be very much in the public conscience, and therefore only used with the strictest of controls in a manner reflecting the caution of the Martens Clause.

Truly autonomous robots should be employed only sparingly, where the *jus in bello* criteria of discrimination, proportionality and military necessity can be satisfied with the utmost confidence, and responsibility for LARs’ actions is clear. Otherwise, full autonomy should be sacrificed through the inclusion of a human on the loop, until such time as the technology catches up.

Even if it might be argued that scientific and popular culture predictions of killer robots may eventually come true, some are against “imposing unrealistic, ineffective or dangerous bans based on sci-fi scenarios of killer robots rather than realistic understandings of the new technologies and their uses.”[341] As many as fifty-one

---

[340] Arkin, *Governing Lethal Behavior*…, 29.

countries are reportedly using or developing military robotics;[342] if LARs are indeed inevitable, then a general ban on LARs like that recommended by Christof Heyns may do more harm than good if it dissuades significant numbers of robotics developers and other interested parties from working to close the legal and ethical gaps in LAR employment.

This paper has demonstrated that, until those gaps are closed, LARs may be employed through the use of exclusion zones, LARspace management and human on the loop supervision, in a manner consistent with the principles of discrimination, proportionality and military necessity with clear responsibility for their actions. Moreover, many stakeholders, including Arkin—a proponent of artificial intelligence—favour some method of overriding or neutralizing LARs.[343] If, as Springer states, "[t]o be truly autonomous, a machine must be allowed to perform its entire function without input from a human operator,"[344] then LARs with a human-controlled override are therefore not truly autonomous, since they are not entirely independent.

In time, LARs or their less-autonomous automatic ancestors may "establish a track record of reliability in finding the right targets and employing weapons properly,"[345] earning enough trust to allow their unsupervised use in battle. Unless or

---

[341] Anderson and Waxman, "Law and Ethics for Autonomous Weapon Systems …," 3.

[342] Noel Sharkey, "Automating warfare is ethically dangerous," *SGR Newsletter* no. 40 (Autumn, 2011), http://www.sgr.org.uk/sites/sgr.org.uk/files/SGRNL40_web.pdf, 6.

[343] See Krishnan, *Killer Robots* …, 163; Thurnher, "No one at the controls …," 83; Arkin, *Governing Lethal Behavior*…, 202–203, 205–207; UK MoD Joint Doctrine Note 2/11, 5-4; and Human Rights Watch and Harvard Law School International Human Rights Clinic, "Losing Humanity …," 36, 42.

[344] Springer, *Military Robots and Drones*…, 2.

[345] John Tirpac, quoted in Stephen Graham, "America's Robot Army," *New Statesman*, 12 June, 2006, http://www.newstatesman.com/node/153371.

until that happens, lethal robots should not be autonomous, but should have a human on the loop in a supervisory or veto capacity, to comply with the *jus in bello* principles of discrimination, proportionality and military necessity as well as the LOAC's requirement for command responsibility.

Various tangential lines of research have been touched on but not explored in this paper. Future work related to LARs might address the impact of LARs with artificial intelligence on the LOAC of the future, particularly questions of personhood and agency; the cultural and operational impact of anthropomorphic LAR design; the role of IFF or sensor acuity in accidents and mishaps; and, if LARs are the next RMA, what will the *RMA after next* be? Perhaps the answer to that question is already suggested in novels or on movie screens, just as robots were predicted almost a century ago and LARs figured in mid-twentieth-century science fiction. Lastly, this paper has focused on lethal autonomous robots. However, its examples of accidents and mishaps involving modern robotic weapons systems have also demonstrated that automated or tele-operated weapon system employment can result in errors and remains contentious in society, making it worthy of further study.

In closing, human society may not be facing extinction by fictitious Terminators any time soon, but it is clearly becoming aware of a dark side of robotics technology. If lethal autonomous robots do become reality, we must ensure that these killer robots remain weapons under human control, and that Emmerich de Vattel's admonition "[l]et us never forget that our enemies are men"[346] still rings true.

[346] Vattel, Emmerich de, *The Law of Nations* (London: n.n., 1740), Book III, section 158, quoted in James Turner Johnson, *Just War Tradition and the Restraint of War* (Princeton: Princeton University Press, 1981), xxxiv.

**BIBLIOGRAPHY**

Abbas, Faisal J.. "New radar system enhances Patriot missiles by up to 50 percent: Raytheon executive." *Al Arabiya News*, 21 February, 2013. http://english.alarabiya.net/articles/2013/02/21/267603.html.

Alexander, Harriet. "'Killer robots' could be outlawed." *The Telegraph*, 14 November 2013. http://www.telegraph.co.uk/news/worldnews/europe/10446724/Killer-Robots-could-be-outlawed.html.

Allen, Colin and Wendell Wallach. "Moral Machines: Contradiction in Terms or Abdication of Human Responsibility." Chap. 4 in *Robot Ethics: The Ethical and Social Implications of Robotics,* 55–68.

Anderson, Kenneth and Matthew Waxman. "Law and Ethics for Autonomous Weapon Systems: Why a Ban Won't Work and How the Laws of War Can." Stanford University Hoover Institution National Security and Law Essay. 9 April, 2013. http://www.hoover.org/research/law-and-ethics-autonomous-weapon-systems-why-ban-wont-work-and-how-laws-war-can.

Arkin, Ronald C. "The Case for Ethical Autonomy in Unmanned Systems." *Journal of Military Ethics* 9, No. 4 (2010): 332–341. http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=56042210&site=ehost-live.

———. *Governing Lethal Behavior in Autonomous Robots*. Boca Raton: CRC Press, 2009.

Asaro, Peter M. "A Body to Kick, but Still No Soul to Damn: Legal Perspectives on Robotics." Chap. 11 in *Robot Ethics: The Ethical and Social Implications of Robotics,* 169–186.

Associated Press. "Ship's anti-missile system may not have worked properly." *Wilmington Morning Star*, 23 May, 1987. http://news.google.com/newspapers?nid=1454&dat=19870523&id=14FRAAAAIBAJ&sjid=6RMEAAAAIBAJ&pg=5630,3256654.

———. "UN report calls for killer robot moratorium." *CBC News*, 2 May 2013. http://www.cbc.ca/news/world/un-report-calls-for-killer-robot-moratorium-1.1386348.

No author. "Attack of the Drones." *Current Events* 109 no. 21 (29 March 2010): 4–5. http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=49091125&site=ehost-live.

BAE Systems. “Taranis.” Last accessed 20 March, 2014. http://www.baesystems.com/enhancedarticle/BAES_157659/taranis?_afrLoop=168568191008000.

Baldor, Lolita C. “Report: Computer Virus hits US Air Force drone program; Pentagon mum on impact.” *The Canadian Press*, 8 October, 2011. http://search.ebscohost.com/login.aspx?direct=true&db=n5h&AN=MYO362981344411&site=ehost-live.

Barnes, Michael J. and William Evans III. “Soldier-Robot Teams in Future Battlefields: An Overview.” Chap. 2 in *Human-Robot Interactions in Future Military Operations*, edited by Michael Barnes and Florian Jentsch. Farnham: Ashgate Publishing, 2009). Kindle Edition.

Bekey, George A. *Autonomous Robots: From Biological Inspiration to Implementation and Control*. Cambridge: MIT Press, 2005. Kindle edition.

———. “Current Trends in Robotics.” Chap. 2 in *Robot Ethics: The Ethical and Social Implications of Robotics,* 17–34.

Borgeit, Alex. “Eliminating the ‘You’ in UMV.” United States Naval Institute. Last accessed 14 May, 2014. http://www.usni.org/eliminating-%E2%80%9Cyou%E2%80%9D-umv.

Brunstetter, Daniel R. “Can We Wage a Just Drone War?” *The Atlantic*, 19 Jul, 2012. http://www.theatlantic.com/technology/archive/2012/07/can-we-wage-a-just-drone-war/260055/.

Byers, Michael. *War Law: Understanding International Law and Armed Conflict*. Vancouver: Douglas & McIntyre, 2005.

Byrnes, Michael W. “Nightfall: Machine Autonomy in Air-to-Air Combat.” *Air & Space Power Journal* 28, No. 3 (May-June 2014): 48–75. http://www.airpower.maxwell.af.mil/digital/pdf/articles/2014-May-Jun/F-Byrnes.pdf.

Cameron, James, Gale Anne Hurd and William Wisher Jr. *The Terminator*. DVD. Directed by James Cameron. 1984; Santa Monica: MGM Home Entertainment, 2006.

Campaign to Stop Killer Robots. “About Us.” Last accessed 14 June, 2014. http://www.stopkillerrobots.org/about-us/.

———. “The Problem.” Last accessed 14 June, 2014. http://stopkillerrobots.org/the-problem/.

———. "The Solution." Last accessed 14 June, 2014. http://stopkillerrobots.org/the-solution/.

———. "Who We Are." Last accessed 14 June, 2014. http://www.stopkillerrobots.org/coalition/.

Canada. Department of National Defence. B-GJ-005-501/FP-001 *Canadian Forces Joint Publication CFJP-5.1, Use of Force for CF Operations*. Ottawa: DND Canada, 29 August, 2008.

———. Department of National Defence. DAOD 3002-0. "Ammunition and Explosives." Last updated 10 November, 2006. http://www.forces.gc.ca/en/about-policies-standards-defence-admin-orders-directives-3000/3002-0.page.

———. Maritime Command. *Gunar/Mk 69 Drill Book*. Halifax: Weapons Division, Canadian Forces Fleet School, 1982.

———. Maritime Command. *Naval Engineering Information*. Esquimalt: VENTURE, the Naval Officer Training Centre, nd..

———. Public Works and Government Services Canada. "Termium Plus." Last accessed 15 April, 2014. http://www.btb.termiumplus.gc.ca/tpv2alpha/alpha-eng.html?lang=eng&i=1&index=alt&__index=alt&srchtxt=ROBOT.

———. Royal Canadian Navy. CFCD 130, *Canadian Navigation Manual*, 2nd ed. Esquimalt: VENTURE, the Naval Officer Training Centre, 2010.

———. Royal Canadian Navy. Maritime Command Order 04-15. "Command, Charge and Control of HMC Ships." February 2008.

———. Royal Canadian Navy. Maritime Command Order 46-3. "Safety Firing Orders for Ships and Submarines." September 2009.

Canning, John S. "Weaponized Unmanned Systems: A Transformational Warfighting Opportunity, Government Roles in Making it Happen." In *Engineering the Total Ship (ETS) 2008 Proceedings*. Falls Church, VA: American Society of Naval Engineers, 23-25 September, 2008. https://www.navalengineers.org/SiteCollectionDocuments/2008%20Proceedings%20Documents/ETS%202008/Canning%20Weaponized%20Unmanned%20Systems%20-%20A%20Transformational%20Opportunity.pdf.

Čapek, Karel. *R.U.R. (Rossum's Universal Robots)*. Translated by David Wyllie. University of Adelaide Library eBook. Last updated 7 March, 2014. http://ebooks.adelaide.edu.au/c/capek/karel/rur/index.html.

Carnegie Science Center. Roboworld. "What is a Robot?" Last accessed 14 March, 2014. http://www.carnegiesciencecenter.org/exhibits/roboworld-what-is-robot/.

Casey-Maslen, Stuart. "Pandora's Box? Drone strikes under *jus ad bellum*, *jus in bello* and international human rights law." *International Review of the Red Cross* 94, No. 886 (Summer 2012): 597–626. http://www.icrc.org/eng/resources/international-review/review-886-new-technologies-warfare/review-886-all.pdf.

Cavas, Christopher P. "U.S. Navy Finds New Ways To Improve Aegis." *Defence News*, 7 April, 2013. http://www.defensenews.com/article/20130407/DEFREG02/304070006/U-S-Navy-Finds-New-Ways-Improve-Aegis.

Claremont, Chris. *X-Men: Days of Future Past*, 2nd ed. Originally published in magazine form as *X-Men* no. 138–141, *Uncanny X-Men* no. 142–143 and *X-Men Annual* no. 4. 1981–1982; New York: Marvel Worldwide, 2014.

Corn, Geoffrey S., Victor Hansen, Richard B. Jackson, Chris Jenks, Eric Talbot Jensen and James A. Schoettler, Jr. *The Law of Armed Conflict: An Operational Approach.* New York: Wolters Kluwer Law & Business, 2012.

Cosgrove-Mather, Bootie. Associated Press. "Robots draw rough duty." *CBS News*, July 30, 2002. http://www.cbsnews.com/news/robots-draw-rough-duty/.

Cowan, Thomas H. "A theoretical, legal and ethical impact of robots on warfare." Masters of Strategic Studies Paper, United States Army War College, 30 March, 2007. http://www.dtic.mil/dtic/tr/fulltext/u2/a469591.pdf.

No author. "The Cylons of *The Plan.*" Bonus feature. *Battlestar Galactica: The Plan*. DVD. Directed by Edward James Olmos. Universal City, CA: Universal Studios Home Entertainment, 2009.

Darack, Ed. "A Brief History of Unmanned Aircraft." *Air & Space/Smithsonian Magazine*, 17 May, 2011. http://www.airspacemag.com/photos/a-brief-history-of-unmanned-aircraft-174072843/?page=8.

Davis, Daniel L. "Who decides: Man or machine?" *Armed Forces Journal*, 1 November, 2007. http://www.armedforcesjournal.com/who-decides-man-or-machine/.

*Defense Update.* "Iron Dome Battle Management Demonstrated." Last accessed 4 July, 2014. http://defense-update.com/photos/iron_dome_bms.html.

Dick, Philip K. “Second Variety,” in *The Best Military Science Fiction of the 20th Century*, edited by Harry Turtledove and Martin H. Greenberg. 1953; Random House Publishing Group, 2001. Kindle edition, locations 667-1600.

DiLego, Francis A. Jr., John Hitchings, Chad Salisbury, Henry X. Simmons, Joshua Sterling and Jialing Cai. “Joint Airspace Management and Deconfliction (JASMAD).” AFRL-RI-RS-TR-2009-13 Final In-House Technical Report. Rome, N.Y.: Air Force Research Laboratory, January 2009. http://handle.dtic.mil/100.2/ADA493585.

Dorn, Walter A. “Just War Tradition and the Ethics of War.” Lecture presentation for Canadian Forces College Joint Command and Staff Programme (JCSP) 39, 4 September, 2012. http://walterdorn.net/pdf/JustWarTradition_Dorn_JCSP39_4Sept2012.pdf.

Driver, Julia. *Ethics: the Fundamentals*. Malden, MA: Blackwell, 2006. Kindle edition.

edX. “Autonomous Mobile Robots.” Last accessed 15 April, 2014. https://www.edx.org/course/ethx/ethx-amrx-autonomous-mobile-robots-1342.

Eshel, David. “Israel Intercept Two Attack UAV Launched by Hezbollah.” *Defense Update*, 14 August, 2006. http://defense-update.com/2006/08/israel-intercept-two-attack-uav.html.

Evans, Nicholas. “Emerging Military Technologies: A Case Study in Neurowarfare.” Chap. 6 in *New Wars and New Soldiers*, edited by Paolo Tripodi and Jessica Wolfendale. Farnham: Ashgate Publishing, 2011.

Ewing, David, Malcom Fuller, Micheal J. Gething and John Williamson. *IHS Jane’s C4ISR & Mission Systems 2013–2014: Maritime*, 2nd ed. Coulsdon: IHS Jane’s, 2013.

Federation of American Scientists. “MK 60 Encapsulated Torpedo (CAPTOR).” Last modified 13 December, 1998. http://www.fas.org/man/dod-101/sys/dumb/mk60.htm.

———. “Naval Weapons Systems.” Chapter 1 in *Fundamentals of Naval Weapons Systems*. Last accessed 18 March 2014. http://www.fas.org/man/dod-101/navy/docs/fun/part01.htm.

Fried, Ina. “Samsung Taps Dick Tracy and the Jetsons to Help Sell Its Galaxy Gear Watch.” 6 October, 2013. http://allthingsd.com/20131006/samsung-taps-dick-tracy-and-the-jetsons-to-help-sell-its-galaxy-gear-watch/.

Frieden, David R., ed. *Principles of Naval Weapons Systems*. Annapolis: Naval Institute Press, 1985.

Friedman, Norman. *The Naval Institute Guide to World Naval Weapons Systems*, 5th ed. Annapolis: Naval Institute Press, 2006.

Gates, Bill. "A Robot in Every Home." *Scientific American* 296, no. 1 (January 2007): 58–65. http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=23362665&site=ehost-live.

Goldsmith, D.A. "Robots in the Battlespace: Moral and Ethical Considerations in the Use of Autonomous Mechanical Combatants." Joint Command and Staff Course New Horizons Paper, Canadian Forces College, 2008.

Greenlaw, J. "Sea mines and naval mine countermeasures: are autonomous underwater vehicles the answer, and is the Royal Canadian Navy ready for the new paradigm?" Masters of Defence Studies Paper, Canadian Forces College, 2013.

Guarini, Marcello and Paul Bello. "Robotic Warfare: Some Challenges in Moving from Noncivilian to Civilian Theaters." Chap. 8 in *Robot Ethics: The Ethical and Social Implications of Robotics,* 129–144.

Guetlein, Mike. "Lethal Autonomous Weapons – Ethical and Doctrinal Implications." Joint Military Operations Paper, United States Naval War College, 14 February 2005. www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA464896.

No author. "Hamas, Hizbullah said to have fleet of drones on Israel border." *Geo-Strategy Direct*, 29 September, 2010: 6. http://search.ebscohost.com/login.aspx?direct=true&db=tsh&AN=55118967&site=ehost-live.

Hammond, Grant T. "On The Making of History: John Boyd and American Security." Harmon Memorial Lecture. United States Air Force Academy, Colorado, 2012. http://www.usafa.edu/df/dfh/docs/Harmon54.pdf.

Handel, Alan and Julian Jones. "How William Shatner changed the world." Directed by Julian Jones. Broadcast on 21 October, 2006. Quoted in P.W. Singer, *Wired for War: The Robotics Revolution and Conflict in the 21st Century*. New York: Penguin Press, 2009.

Handlin, Oscar. "Science and Technology in Popular Culture," *Daedalus* 94, no. 1 (Winter 1965): 156–170, http://www.jstor.org/stable/20026900.

Harmon, S.Y. and D.W. Gage. "Current technical research issues of autonomous robots employed in combat." In *Proceedings of EASCON 1984:17th Annual Electronics and Aerospace Conference*. Washington D.C.: Institute of Electrical and Electronics Engineers, 11–13 September 1984: 215–219. http://www.public.navy.mil/spawar/Pacific/Robotics/Documents/Publications/1984/eascon84.pdf.

Holley, I.B. Jr. "The Role of Doctrine." Chap. 1 in *Technology and Military Doctrine: Essays on a Challenging Relationship*. Maxwell AFB, Alabama: Air University Press, August 2004. http://aupress.maxwell.af.mil/digital/pdf/book/b_0093_holley_technology_military_doctrine.pdf.

Hopkins, Nick. "Afghan civilians killed by RAF drone." *The Guardian,* 5 July, 2011. http://www.theguardian.com/uk/2011/jul/05/afghanistan-raf-drone-civilian-deaths.

Hughes, Emma and Jenny Kitzinger. "Science Fiction Fears? An analysis of how people use fiction in discussing risk and emerging science and technology." SCARR Working Paper 28-2008, Cardiff School of Journalism, Media and Cultural Studies Cardiff University, Cardiff, Wales, 2008. http://www.kent.ac.uk/scarr/papers/HughesKitzingerWkPpr28.pdf.

Human Rights Watch. "UN: Start International Talks on 'Killer Robots.'" November 13, 2013. http://www.hrw.org/news/2013/11/13/un-start-international-talks-killer-robots.

Human Rights Watch and Harvard Law School International Human Rights Clinic. "Losing Humanity: The Case Against Killer Robots." November, 2012. http://www.hrw.org/sites/default/files/reports/arms1112ForUpload_0_0.pdf.

Husain, Haroon. "Iron Dome counter - rocket, artillery and missile (C-RAM) system." *Defence Journal* 16 No. 9 (April 2013): 52–56. http://search.ebscohost.com/login.aspx?direct=true&db=tsh&AN=87618529&site=ehost-live.

IHS Technology. Market Watch. "Voice Recognition Installed in More than Half of New Cars by 2019." 19 March, 2013. https://technology.ihs.com/427146/voice-recognition-installed-in-more-than-half-of-new-cars-by-2019.

IMDb. "RoboCop (1987)." Last accessed 4 June, 2014. http://www.imdb.com/title/tt0093870/.

———."Short Circuit (1986)." Last accessed 19 July, 2014. http://www.imdb.com/title/tt0091949/.

———. "X-Men: Days of Future Past (2014)." Last accessed 1 July, 2014. http://www.imdb.com/title/tt1877832/.

Intel. "Moore's Law Inspires Intel Innovation." Last accessed 15 April, 2014. http://www.intel.com/content/www/us/en/silicon-innovations/moores-law-technology.html.

International Committee for Robot Arms Control. "Home." Last accessed 14 June, 2014. http://icrac.net/.

———. "Statements." Last accessed 14 June, 2014. http://icrac.net/statements/.

———. "Who we are." Last accessed 14 June, 2014. http://icrac.net/who//.

International Committee of the Red Cross. "Autonomous weapons: States must address major humanitarian, ethical challenges." Last updated 11 July, 2014. http://www.icrc.org/eng/resources/documents/faq/q-and-a-autonomous-weapons.htm.

———. "Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on their Destruction, 18 September 1997 – Preamble." Last accessed 28 July, 2014. http://www.icrc.org/applic/ihl/ihl.nsf/Article.xsp?action=openDocument&documentId=D4526D1EB0F4AF1241256585003DD6A1.

———. "IHL and other legal regimes – jus ad bellum and jus in bello." Last updated 24 November, 2010. http://www.icrc.org/eng/war-and-law/ihl-other-legal-regmies/jus-in-bello-jus-ad-bellum/overview-jus-ad-bellum-jus-in-bello.htm.

———. "International Humanitarian Law – Answers to Your Questions." October, 2002. http://www.icrc.org/eng/assets/files/other/icrc_002_0703.pdf.

———. *International Review of the Red Cross* 94, No. 886 (Summer 2012). http://www.icrc.org/eng/resources/international-review/review-886-new-technologies-warfare/review-886-all.pdf.

———. "The law of armed conflict – Lesson 1 – Basic Knowledge." Lecture presentation. June, 2002. http://www.icrc.org/eng/assets/files/other/law1_final.pdf.

———. Protocol Additional to the Geneva Conventions of 12 August 1949, and relating to the Protection of Victims of International Armed Conflicts (Protocol I), 8 June 1977. "Commentary – New weapons." Last accessed 13 June, 2014. http://www.icrc.org/applic/ihl/ihl.nsf/1a13044f3bbb5b8ec12563fb0066f226/f095453e41336b76c12563cd00432aa1.

———. Resource Centre. “Autonomous weapons: ICRC addresses meeting of experts.” Last updated 5 June, 2014. http://www.icrc.org/eng/resources/documents/statement/2014/05-13-autonomous-weapons-statement.htm.

———. Resource Centre. “Autonomous weapons: States must address major humanitarian, ethical challenges.” Last updated 6 June, 2014. http://www.icrc.org/eng/resources/documents/faq/q-and-a-autonomous-weapons.htm.

———. “Treaties and States Party to Such Treaties.” Last accessed 20 Jun, 2014. http://www.icrc.org/applic/ihl/ihl.nsf/vwTreatiesByDate.xsp.

———. “War and international humanitarian law.” Last updated 3 July, 2014. http://www.icrc.org/eng/war-and-law/.

International Federation of Robotics. “Executive Summary – World Robotics 2013.” http://www.ifr.org/uploads/media/Executive_Summary_WR_2013.pdf.

iRobot Corporation. “Your Home, Our Robots.” Last accessed 18 July, 2014. http://www.irobot.com/us/learn/home.aspx.

Israel. Israeli Air Force. “Israel Aircraft Industries ‘Scout.’” Last accessed 10 July, 2014. http://www.iaf.org.il/215-en/IAF.aspx.

Jewell, Lorie. “Armed Robots to March into Battle.” *United States Department of Defense – Transformation*. 6 December, 2004. http://www.defense.gov/transformation/articles/2004-12/ta120604c.html.

Johnson, James Turner. *Can Modern War Be Just?* New Haven: Yale University Press, 1984.

———. “Politics, Power and the International Order.” Chapter 1 in *Morality and Contemporary Warfare*. New Haven: Yale University Press, 1999.

Kelly, Christopher J. “The submarine force in joint operations.” Air Command and Staff College Research Report AU/ASC/145/1998-04, Air University, April 1998. https://www.fas.org/man/dod-101/sys/ship/docs/98-145.pdf.

Kerr, Ian. “Keep killer robots fictional.” *Ottawa Citizen*, 26 April, 2014. http://www.ottawacitizen.com/opinion/op-ed/Keep+killer+robots+fictional/9780860/story.html.

Klochendler, Pierre. "Drone Technology Takes Off." *Interpress News Agency*, 29 March, 2012. http://www.ipsnews.net/2012/03/drone-technology-takes-off/.

Knott, Alexander. "C2 in Robotic Warfare," briefing slides with scripted commentary, Carlisle Barracks, U.S. Army War College, Joint Robotics Course CC2213, April 2006. Quoted in Thomas H. Cowan, "A theoretical, legal and ethical impact of robots on warfare," Masters of Strategic Studies Paper, United States Army War College, 30 March, 2007. http://www.dtic.mil/dtic/tr/fulltext/u2/a469591.pdf, 10.

Knox, MacGregor and Williamson Murray, ed. *The Dynamics of Military Revolution, 1300 – 2050*. Cambridge: Cambridge University Press, 2001. Kindle Edition.

Krishnan, Armin. *Killer Robots: Legality and Ethicality of Autonomous Weapons*. Farnham: Ashgate Publishing, 2009. Kindle Edition.

Kumagai, Jean. "A Robotic Sentry For Korea's Demilitarized Zone." *IEEE Spectrum.* 1 March, 2007. http://spectrum.ieee.org/robotics/military-robots/a-robotic-sentry-for-koreas-demilitarized-zone.

Lacroix-Wilson, Jeff. "Canada versus killer robots: Groups want federal government to lead charge against high-tech death machines." *Ottawa Citizen*, 28 April, 2014. http://www.ottawacitizen.com/technology/Canada+versus+killer+robots+Groups+want+federal+government/9788399/story.html.

Lambert, Alyssa E. "More recalls, lawsuits for da Vinci surgical robots." *Trial*, 9 January, 2014. http://www.justice.org/cps/rde//justice/hs.xsl%20/22569.htm.

Lazarski, Anthony J. "Legal Implications of the Uninhabited Combat Aerial Vehicle." *Aerospace Power Journal* 16, No. 2 (Summer 2002): 74–83. http://www.airpower.maxwell.af.mil/airchronicles/apj/apj02/sum02/sum02.pdf.

Lewis, Michael W. "The Law of Aerial Bombardment in the 1991 Gulf War." *American Journal of International Law* 97, No. 3 (July, 2003): 481-509. http://www.jstor.org/stable/3109837.

Lin, Patrick, George Bekey and Keith Abney. "Autonomous Military Robotics: Risk, Ethics, and Design." Funded by the U.S. Department of Defense/Office of Naval Research. December 20, 2008. http://ethics.calpoly.edu/ONR_report.pdf.

Lin, Patrick. "Introduction." Chap. 1 in *Robot Ethics: The Ethical and Social Implications of Robotics,* 3–15.

Lin, Patrick, Keith Abney and George A. Bekey, ed. *Robot Ethics: The Ethical and Social Implications of Robotics*. Cambridge, Massachusetts: MIT Press, 2012.

*The Local – Sweden's News in English*. "Robot attacked Swedish factory worker." Last updated 28 April, 2009. http://www.thelocal.se/20090428/19120.

Lockheed Martin. "Where in the World is Aegis." Last accessed 20 March, 2014. http://www.lockheedmartin.ca/us/products/aegis/where-in-the-world-is-aegis.html.

Makin, N.S. "Future warfare or folly? Autonomous weapon systems on the battlefield: an assessment of ethical and legal implications in their potential use." Masters of Defence Studies Paper, Canadian Forces College, 2008.

Maloney, Sean. "'Was It Worth It?' Canadian Intervention in Afghanistan and Perceptions of Success and Failure." *Canadian Military Journal* 14, No. 1 (Winter 2014): 19–31.

McGarry, Brendan. "Drones Most Accident-Prone U.S. Air Force Craft: BGOV Barometer." *Bloomberg Government*, 18 Jun, 2012. http://www.bloomberg.com/news/2012-06-18/drones-most-accident-prone-u-s-air-force-craft-bgov-barometer.html.

Michaelsen, Christopher. "Maritime Exclusion Zones in Times of Armed Conflict at Sea: Legal Controversies Still Unresolved." *Journal of Conflict & Security Law* 8, No. 2 (October 2003): 363–390. http://search.ebscohost.com/login.aspx?direct=true&db=tsh&AN=44546855&site=ehost-live.

Military History Monthly. "Back to the Drawing Board – The Goliath Tracked Mine." Last modified 12 July, 2012. http://www.military-history.org/articles/back-to-the-drawing-board.htm.

Miller, Gabriel. "Smart enough to kill?" *C4ISR* (June 1, 2013): 14. www.proquest.com.

Moshkina, Lilia and Ronald C. Arkin. "Lethality and Autonomous Systems: Survey Design and Results." Georgia Tech GVU Center Technical Report GIT-GVU-07-16. 2008. http://www.cc.gatech.edu/ai/robot-lab/online-publications/MoshkinaArkinTechReport2008.pdf.

Nimoy, Leonard, Lawrence Konner, Mark Rosenthal, Nicholas Meyer and Denny Martin Flynn. "Space Battle." *Star Trek VI: The Undiscovered Country*. DVD. Directed by Nicholas Meyer. 1991; Hollywood: Paramount Home Video, 1998.

Nocks, Lisa. *The Robot: The Life Story of a Technology*. Westport: Greenwood Press, 2007.

North Atlantic Treaty Organization. Combined Joint Operations from the Sea Centre of Excellence. *Guidance for developing Maritime Unmanned Systems (MUS) capability*. Norfolk: NATO, 9 July 2012. http://cjoscoe.org/docs/MUS_Final_9July2012.pdf.

Northrop Grumman. Capabilities. "X-47B UCAS." Last accessed 20 March, 2014. http://www.northropgrumman.com/Capabilities/X47BUCAS/Pages/default.aspx.

———. Facts. "RQ-4 Global Hawk High-Altitude, Long-Endurance Unmanned Aerial Reconnaissance System." Last modified May, 2008. http://www.northropgrumman.com/Capabilities/RQ4Block10GlobalHawk/Documents/HALE_Factsheet.pdf.

Norton-Taylor, Richard and Rob Evans. "The Terminators: drone strikes prompt MoD to ponder ethics of killer robots." *The Guardian*, 17 April 2011. http://www.theguardian.com/world/2011/apr/17/terminators-drone-strikes-mod-ethics.

Orend, Brian. *The Morality of War*, 2nd ed. Peterborough: Broadview Press, 2013. Adobe Digital Edition.

Page, Lewis. "US war robots in Iraq 'turned guns' on fleshy comrades." *The Register*, 11 April, 2008. http://www.theregister.co.uk/2008/04/11/us_war_robot_rebellion_iraq/.

Patel, Sutchin R., and Gyan Pareek. "The History of Robotics In Urology." *Medicine & Health Rhode Island* 92, no. 10 (October 2009): 325–326. http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=44722671&site=ehost-live.

Patton, Phil. "Robots with the Right Stuff." *Wired* 4.03, March 1996. Last accessed 19 July, 2014. http://archive.wired.com/wired/archive/4.03/robots.html?pg=5&topic.

Pilkington, Ed. "'Killer robots' pose threat to peace and should be banned, UN warned." *The Guardian*, 29 May, 2013. http://www.theguardian.com/science/2013/may/29/killer-robots-ban-un-warning.

Pocock, Chris. "UAV Crash in Korea Linked To GPS Jamming." *AINonline*. 1 June, 2012. http://www.ainonline.com/aviation-news/ain-defense-perspective/2012-06-01/uav-crash-korea-linked-gps-jamming.

*Popular Mechanics*. "The Inside Story of the SWORDS Armed Robot 'Pullout' in Iraq: Update." October 1, 2009. http://www.popularmechanics.com/technology/gadgets/4258963.

QinetiQ. "QinetiQ North America Ships First MAARS Robot." 5 June, 2008. http://www.qinetiq.com/media/news/releases/Pages/qna-ships-first-maars-robot.aspx.

QinetiQ North America. "MAARS." Last accessed 19 May, 2014. https://www.qinetiq-na.com/products/unmanned-systems/maars/.

Raytheon Company. "Phalanx Close-In Weapons System (CIWS)." Last accessed 20 March, 2014. http://www.raytheon.com/capabilities/products/phalanx/.

Roberts, Adam. *Science Fiction (The New Critical Idiom)*, 2nd ed. London: Taylor and Francis, 2006. Kindle edition.

Roddenberry, Gene, D.C. Fontana and Laurence N. Wolfe. "The Ultimate Computer." *Star Trek*, Season Two Remastered DVD Edition. Directed by John Meredyth Lucas. 1968; Hollywood: CBS DVD, 2008.

Roddenberry, Gene and John Meredyth Lucas. "The Changeling." *Star Trek*, Season Two Remastered DVD Edition. Directed by Marc Daniels. 1967; Hollywood: CBS DVD, 2008.

Sauer, Frank and Niklas Schőrnig. "Killer drones: The 'silver bullet' of democratic warfare?" *Security Dialogue* 43(4) (2012): 363–380; Sage database: www.sdi.sagepub.com/content/43/4/463.

Shaker, Steven M. and Alan R. Wise. *War without Men: Robots on the Future Battlefield*. MacLean, VA: Pergamon-Brassey's, 1988.

Sharkey, Noel. "Automating warfare is ethically dangerous." *SGR Newsletter* no. 40 (Autumn, 2011). http://www.sgr.org.uk/sites/sgr.org.uk/files/SGRNL40_web.pdf.

———. "Cassandra or false prophet of doom: AI robots and war." *IEEE Intelligent Systems* 23, No. 4 (July 1, 2008): 14–17.

———. "The evitability of autonomous robot warfare." *International Review of the Red Cross* 94, No. 886 (Summer 2012): 787–799. http://www.icrc.org/eng/assets/files/review/2012/irrc-886-sharkey.pdf

———. Interviewed in "Video game aces 'will wage wars of the future using killer robots.'" *The Mail Online*, 24 February, 2012. http://www.dailymail.co.uk/sciencetech/article-2283941/Video-game-aces-wage-wars-future-using-killer-robots.html.

———. "Saying 'No!' to Lethal Autonomous Targeting." *Journal of Military Ethics* 9, No. 4, (2010): 369–383.

http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=56042208&site=ehost-live.

Siegwart, Roland, Iliah R. Nourbakhsh and Davide Scaramuzza. *Introduction to autonomous mobile robots,* 2nd ed. Cambridge: MIT Press, 2011.

Singer, P.W. "Drones Don't Die - A History of Military Robotics." Last modified May 5, 2011. http://www.historynet.com/drones-dont-die-a-history-of-military-robotics.htm.

———. *Wired for War: The Robotics Revolution and Conflict in the 21st Century*. New York: Penguin Press, 2009.

Smith, Adam. "How close were the Terminator films to the reality of 2011?" *BBC News - Technology*, 21 April 2011. http://www.bbc.co.uk/news/technology-13159616.

Sofge, Eric. "Non-Answer on Armed Robot Pullout From Iraq Reveals Fragile Bot Industry." *Popular Mechanics*, 1 October, 2009. http://www.popularmechanics.com/technology/gadgets/4258103.

———. "Tale of the Teletank: The Brief Rise and Long Fall of Russia's Military Robots." *Popular Science*, 7 March, 2014. http://www.popsci.com/blog-network/zero-moment/tale-teletank-brief-rise-and-long-fall-russia%E2%80%99s-military-robots.

———. "Top 5 Bomb-Packing, Gun-Toting War Bots the U.S. Doesn't Have." *Popular Mechanics.* 1 October, 2009. http://www.popularmechanics.com/technology/military/4249209.

Sparrow, Robert. "Robotic Weapons and the Future of War." Chap. 7 in *New Wars and New Soldiers*, edited by Paolo Tripodi and Jessica Wolfendale. Farnham: Ashgate Publishing, 2011.

Spielmann, Peter James. Associated Press. "Israeli killer robots could be banned under UN proposal." *The Times of Israel*, 3 May 2013. http://www.timesofisrael.com/israeli-killer-robots-could-be-banned-under-un-proposal/.

Springer, Paul J. *Military robots and drones: a reference handbook*. Santa Barbara: ABC-Clio, 2013.

Subbaraman, Nidhi. "'Terminator' on hold? Debate to stop killer robots takes global stage." *NBC News*, 21 October, 2013. http://www.nbcnews.com/#/tech/innovation/terminator-hold-debate-stop-killer-robots-takes-global-stage-f8C11433704;

Takayama, Leila, Wendy Ju, and Clifford Nass, "Beyond Dirty, Dangerous, and Dull: What Everyday People Think Robots Should Do." Paper presented at the 3rd ACM/IEEE Conference on Human-Robot Interaction, 15 March, 2008: 25–32. http://chime.stanford.edu/wp-content/uploads/2012/09/beyond-dirty-dangerous-and-dull.pdf.

Thurnher, Jeffrey S.. "No one at the controls: Legal implications of fully autonomous targeting." *Joint Force Quarterly* 67 (4th Quarter, October 2012): 77–84. http://www.dtic.mil/doctrine/jfq/jfq-67.pdf.

*Time Magazine*. Best Inventions of 2004. "Robo-Soldier." Last accessed 20 March 2014. http://content.time.com/time/specials/packages/article/0,28804,1940424_1940475_1940638,00.html.

Tirpac, John. Quoted in Stephen Graham. "America's Robot Army," *New Statesman*, 12 June, 2006. http://www.newstatesman.com/node/153371.

Turtledove, Harry. "Introduction," in *The Best Military Science Fiction of the 20th Century*, edited by Harry Turtledove and Martin H. Greenberg. Random House Publishing Group, 2001. Kindle edition.

United Kingdom. Ministry of Defence. Joint Doctrine Note 2/11. *The UK Approach to Unmanned Aircraft Systems.* Shrivenham: Development, Concepts and Doctrine Centre, 30 March 2011. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/33711/20110505JDN_211_UAS_v2U.pdf.

United Nations. International Standards for Humanitarian Mine Clearance Operations. "Section Four – Minefield Marking." Last accessed 15 May 2014. http://www.un.org/Depts/mine/Standard/chap_4.htm.

———. Protocol Additional to the Geneva Conventions of 12 August 1949, and relating to the protection of victims of international armed conflicts (Protocol I), 8 June, 1977. 1125 U.N.T.S. 17512. Available at https://treaties.un.org/doc/Publication/UNTS/Volume%201125/volume-1125-I-17512-English.pdf.

United Nations General Assembly. A/65/321, *Interim report of the Special Rapporteur on extrajudicial, summary or arbitrary executions*. August 23, 2010. http://daccess-dds-ny.un.org/doc/UNDOC/GEN/N10/492/39/PDF/N1049239.pdf?OpenElement

———. A/HRC/23/47, *Report of the Special Rapporteur on extrajudicial, summary or arbitrary executions, Christof Heyns*. April 9, 2013.

http://www.ohchr.org/Documents/HRBodies/HRCouncil/RegularSession/Session23/A-HRC-23-47_en.pdf.

United Nations Mine Action Service. Landmine and Explosive Remnants of War Safety Handbook, 2nd ed. New York: United Nations, 2005. http://www.mineaction.org/sites/default/files/publications/Landmine_and_ERW_Safety_Handbook_0.pdf.

United Nations Office at Geneva. "Advanced version – Report of the 2014 informal Meeting of Experts on Lethal Autonomous Weapons Systems (LAWS)." Last accessed 20 June, 2014. http://www.unog.ch/80256EDD006B8954/(httpAssets)/350D9ABED1AFA515C1257CF30047A8C7/$file/Report_AdvancedVersion_10June.pdf.

———. "CCW – Latest Information." Last accessed 20 June, 2014. http://www.unog.ch/80256EE600585943/(httpPages)/3CFCEEEF52D553D5C1257B0300473B77?OpenDocument.

———. "The Convention on Certain Conventional Weapons." Last accessed 20 June, 2014. http://www.unog.ch/80256EE600585943/(httpPages)/4F0DEF093B4860B4C1257180004B1B30?OpenDocument.

———. "Diplomatic Conference for the Adoption of a Convention on Cluster Munitions." 30 May, 2008. http://www.unog.ch/80256EDD006B8954/(httpAssets)/CE9E6C29A6941AF1C12574F7004D3A5C/$file/ccm77_english.pdf.

United Nations Office of the High Commission for Human Rights. "A Call for a moratorium on the development and use of lethal autonomous robots." Last modified 31 May, 2013. http://www.ohchr.org/EN/NewsEvents/Pages/Acallforamoratoriumonthedevelopmentrobots.aspx.

*United Press International*. "Military develops a Star Trek-like phaser." 1 December, 2005, http://www.upi.com/Science_News/2005/12/01/Military-develops-a-Star-Trek-like-phaser/UPI-88721133463599/.

United States of America. Department of Defense. 14-S-0553, *Unmanned Systems Integrated Roadmap FY 2013-2038*. n.d.. http://www.defense.gov/pubs/DOD-USRM-2013.pdf.

———. Department of Defense. Department of Defense Directive 3000.09, *Autonomy in Weapons Systems*. Washington: Deputy Secretary of Defense, 21 November, 2012. http://www.dtic.mil/whs/directives/corres/pdf/300009p.pdf.

———. Department of Defense. JP 1-02, *Department of Defense Dictionary of Military and Associated Terms.* Washington: Joint Chiefs of Staff, 15 June 2014. http://www.dtic.mil/doctrine/new_pubs/jp1_02.pdf.

———. National Institute of Standards and Technology. NIST Special Publication 100-I-2.0, *Autonomy levels for Unmanned Systems (ALFUS) Framework – Volume I: Terminology.* Edited by Hui-Min Huang. October 2008. http://www.nist.gov/el/isd/ks/upload/NISTSP_1011-I-2-0.pdf.

———. National Institute of Standards and Technology. NIST Special Publication 100-II-1.0, *Autonomy levels for Unmanned Systems (ALFUS) Framework – Volume II: Framework Models.* Edited by Hui-Min Huang. December 2007. http://www.nist.gov/customcf/get_pdf.cfm?pub_id=823618.

———. Office of the Secretary of Defense. "Unmanned Aircraft Systems Roadmap: 2005 – 2030." Washington: Department of Defense, August 4, 2005. http://www.fas.org/irp/program/collect/uav_roadmap2005.pdf.

———. Office of the Secretary of Defense. "Unmanned Aerial Vehicles Roadmap: 2000 – 2025." April 2001. http://www.hsdl.org/?view&did=705358.

———. Office of the Secretary of Defense. "Unmanned Aerial Vehicles Roadmap: 2002 – 2027." December 2002. http://www.nasa.gov/centers/dryden/pdf/111759main_DoD_UAV_Roadmap_2003.pdf.

———. Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics. *Report of the Defense Science Board Task Force on Patriot System Performance – Report Summary*. Washington: Department of Defense, January, 2005. http://www.acq.osd.mil/dsb/reports/ADA435837.pdf.

———. United States Air Force. "MQ-1B Predator." Last modified 20 July, 2010. http://www.af.mil/AboutUs/FactSheets/Display/tabid/224/Article/104469/mq-1b-predator.aspx.

———. United States Army. FM 3-24/MCWP 3-33.5, *Insurgencies and Countering Insurgencies*. 2 June, 2014. http://armypubs.army.mil/doctrine/DR_pubs/dr_a/pdf/fm3_24.pdf.

———. United States Army. FM 34-25-2, "Airspace Management." Chapter 3 of *Unmanned Aerial Vehicles Test Draft*. June, 1995. https://www.fas.org/irp/doddir/army/fm34-25-2/25-2ch3.pdf.

———. United States Navy Fact File. "Mk 15 – Phalanx Close-In Weapons System (CIWS)." Last updated 15 November, 2013. http://www.navy.mil/navydata/fact_display.asp?cid=2100&tid=487&ct=2.

Vattel, Emmerich de. *The Law of Nations*. London: n.n., 1740: Book III, section 158. Quoted in James Turner Johnson, *Just War Tradition and the Restraint of War.* Princeton: Princeton University Press, 1981, xxxiv.

Vintar, Jeff and Akiva Goldsman. "Susan Calvin's Tour of USR." *I, Robot*. DVD. Directed by Alex Proyas. Beverly Hills: Twentieth Century Fox Home Entertainment, 2004.

*Washington Times*. "Robotic warfare drawing nearer." 9 February 2005. http://www.washingtontimes.com/news/2005/feb/9/20050209-113147-1910r/?page=all.

Weinberger, Sharon. "Armed Robots Still in Iraq, But Grounded (Updated)." *Wired*, 15 April, 2008. http://www.wired.com/2008/04/armed-robots-st/.

Willsher, Kim. "French fighter planes grounded by computer virus." *The Telegraph*, 7 February, 2009. http://www.telegraph.co.uk/news/worldnews/europe/france/4547649/French-fighter-planes-grounded-by-computer-virus.html.

Wilson, George C. "Navy Missile Downs Iranian Jetliner." *Washington Post*, Monday, July 4, 1988. http://www.washingtonpost.com/wp-srv/inatl/longterm/flight801/stories/july88crash.htm.

Wilson, S.S. and Brent Maddock. *Short Circuit*. DVD. Directed by John Badham. 1986; Chatsworth: Image Entertainment, 2011.

Wise, Harold Lee. *Inside the Danger Zone: The U.S. Military in the Persian Gulf, 1987-1988*. Annapolis: Naval Institute Press, 2013. Kindle Edition.

Woodward, Sandy and Patrick Robinson. *One Hundred Days: The Memoirs of the Falklands Battle Group Commander*, 3rd ed. London: HarperPress, 2012. Kindle Edition.

Young, Timothy C. "Maritime Exclusion Zones: A Tool for the Operational Commander?" Final course paper, United States Naval War College, 18 May, 1992. http://www.dtic.mil/dtic/tr/fulltext/u2/a253218.pdf.