Robots on the Battlefield

Contemporary Issues and Implications for the Future

Ronan Doaré, Didier Danet,
Jean-Paul Hanon, & Gérard de Boisboissel
General Editors

Combat Studies Institute Press
US Army Combined Arms Center
Fort Leavenworth, Kansas

Ecoles de
Saint-Cyr Coétquidan

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **JAN 2014**	2. REPORT TYPE	3. DATES COVERED **00-00-2014 to 00-00-2014**

4. TITLE AND SUBTITLE **Robots on the Battlefield. Contemporary Perspectives and Implications for the Future**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **US Army Combined Arms Center,Combat Studies Institute,Fort Leavenworth,KS,66027**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR’S ACRONYM(S)
	11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**301**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

Cover Photos:

Photo #1. American Soldier, taken from “A Statement on the Posture of the United States Army, 2010,” submitted by the Honorable John M. McHugh and General Gearoge W. Casey, Jr. to Committees and Subcommittees of the United States Senate and the House of Representatives, February 2010, page 15; https://secureweb2.hqda.pentagon.mil/VDAS_ArmyPostureStatement/2010/2010_army_posture_statement.pdf. Copyright Reprint permissions (CGSC Copyright Registration #10-1045 C/E), United States.

Photo #2. French Soldier. Source: Saint-Cyr French Military Academy - 56381 GUER Cedex, France, 9 November 2011.

Photo #3. French Robot, ECA. Source: Saint-Cyr French Military Academy - 56381 GUER Cedex, France, 9 November 2011.

Robots on the Battlefield

Contemporary Perspectives and Implications for the Future

by
Ronan Doaré, Didier Danet, Jean-Paul Hanon, and Gérard de Boisboissel
General Editors

Combat Studies Institute Press
US Army Combined Arms Center
Fort Leavenworth, Kansas

Ecoles de Saint-Cyr Coëtquidan

Library of Congress Cataloging-in-Publication Data

Library of Congress Control Number: 2013957146

First Printing January 2014

Layout and Design by
Elizabeth J. Brown
Combat Studies Institute Press

Combat Studies Institute Press publications cover a wide variety of military history topics. The views expressed in this CSI Press publication are those of the author(s) and not necessarily those of the Department of the Army or the Department of Defense. A full list of digital CSI Press publications is available at http:/ usacac.army.mil/CAC2/CSI/index.asp.

Acknowledgements

This project was made possible thanks to the financial support of the Délégation aux Affaires Stratégiques (Directorate for Strategic Affairs, French MoD) which funded translations of several of the chapters in this collection.

Selected chapters in this anthology were previously published in Ronan Doaré and Henri Hude (eds.) *Les robots au coeur du champ de bataille* (Paris, 2011). Permission to publish English translations of these chapters in this collection has been granted by the original publisher, Les Editions Economica.

Selected chapters in this anthology were previously published in Didier Danet, Jean-Paul Hanon, and Gérard de Boisboissel (eds.) *La guerre robotisée* (Paris, 2012). Permission to publish English translations of these chapters in this collection has been granted by the original publisher, Les Editions Economica.

"The Use of Robots on the Battlefield: Benefits, Constraints, and Limitations for Soldiers" by Gérard de Boisboissel was previously published in Vaclav Krivanek and Alexandr Stefek (eds.) International Conference in Military Technology Proceedings (ICMT), (Brno, 2013). Permission to publish an English translation of this chapter in this collection has been granted by the original publisher.

Foreword

Technological implications are often less obvious than technological innovations. Learning the uses and the limitations of any new technology can take a long time... subsequent generations are apt to regard those who go through this process as having held antiquated, even weird, notions.

—John Lewis Gaddis

Technological innovation brings with it the promise of greater efficiency. This is particularly true for innovations applied to the implements of war. Moreover, at punctuated intervals throughout human history technical and scientific developments have resulted in a nonlinear change of both battlefield tactics and national strategies. The airplane, the tank, and the magazine-fed rifle are modern examples, but the bow and the stirrup had equally revolutionary impacts on the armies of their times and later. Still, the process of innovation and the many avenues of exploration required before success is achieved can desensitize those who witness it. Since 2001, the United States and its allies have employed a host of unmanned or remote-operated "robotized" devices to support military operations both on the ground and in the air. The proliferation of this technology tends to lessen our recognition of its potential to dramatically change the character of warfare. Although much of the world's current experience with ground robots is directly related to the clearing of mines and IEDs, it is not unreasonable to expect that within the lifetimes of current flesh-and-blood soldiers the world will witness the first use of mechanical "soldiers." Because of that, and because robotics offer both state and non-state actors a truly bloodless and potentially revolutionary alternative to traditional combat, the arguments presented in the following chapters are both timely and appropriate. The first cooperative publishing effort between the Combat Studies Institute and Les Ecoles de St. Cyr Coëtquidan, this volume should spark further discussion between policy-makers and military practitioners, as well as among ethicists, scientists, and acquisition specialists. The Combat Studies Institute is indebted to Brigadier-General Antoine Windek and the contributing authors for choosing our press to bring to this volume to the English-speaking world.

Colonel Thomas E. Hanson
Director
Combat Studies Institute

Preface

Robots on the Battlefield is the first work published in the United States by the Ecoles de Saint-Cyr Coëtquidan, the French military officer training facility. It is the fruit of cooperation with the Combat Studies Institute of the US Army Combined Arms Center, whom I wish to thank for their active part in this initiative. I look forward to seeing other joint publications from this original cooperation in the future.

The issues of this work are those to which everyone interested in or concerned with the world of defense at the highest level—members of the armed forces, as well as political leaders, industrialists, NGOs and university faculty in every field—should pay attention. As the school which trains the future officers of the French Army, Saint-Cyr Coëtquidan is no stranger to these issues. Saint-Cyr Coëtquidan has contributed to the discussion on robotization through a research program and a series of special events, a high point of which was an international colloquium in November 2011, attended by delegates from West Point, Annapolis, and Quantico, among others. *Robots on the Battlefield* also includes major contributions from talks at workshops and colloquia held as part of the Ecoles de Saint-Cyr Coëtquidan research program.

The theme of robotization of the battlefield is approached here from the angle of social and political sciences. The work does not cover scientific and technical aspects of the question but concentrates on legal, ethical, psychological, sociological, tactical, and strategic issues, in order to provide an overview of how the amazing development of military robots is going to change the conditions under which our armed forces act: preventing conflicts, coming between hostile parties, military intervention per se, and stabilizing and reconstructing the countries concerned. Without necessarily evoking "robolution" (the idea that robotization has led to revolutionary change and a turning point in military history), the multiplication of remotely controlled machines, some of which are capable of autonomous decisions and actions, transforms the conditions of using force and raises a number of questions about opportunities and threats: the balance of costs, advantages and risks; operational and budgetary priorities; compatibility with the laws of armed combat and military ethics; the organization of forces; the use of robots in conjunction with other arms; tactical changes; the impact on enemies and the population; and, more broadly, a change in the very sense of the military profession.

To answer these diverse and complex questions, the *Pôle Action Globale et Forces Terrestres* (the Saint-Cyr Coëtquidan Global Action & Land Forces Research Center) has been conducting a research program with a wide range of experts representing various stakeholders in the field of battlefield robotics. The majority of these experts have a European perspective, which North American readers may find less familiar, but which, I hope, they will enjoy discovering. The work includes analyses by leaders of the French armed forces, by industrialists in the field, and by university professors specializing in defense issues. American readers will of course be on familiar ground with major contributions from our colleagues from the US Military Academy, the US Naval Academy and the Marine Corps University, whom we thank wholeheartedly for their involvement in this research program.

The *Ecole Spéciale Militaire de Saint-Cyr,* founded in 1802 by first consul Napoleon Bonaparte just before the Battle of Austerlitz, has trained future officers of the French Army for over two centuries. The school's graduates include a long line of military figures who distinguished themselves in battlefields around the globe, including Hubert Lyautey, Joseph Galliéni, Charles De Gaulle, and Jean de Lattre de Tassigny. The school's mission is to provide French and foreign students with an education on one campus that combines academic excellence, thorough a grounding in military science and demanding physical training. The school's research work, of which *Robots on the Battlefield* is one result, aims to understand better the nature and scope of changes in international conflicts in order to enrich the palette of knowledge useful for training cadets so that they are prepared as well as possible to face difficult situations and understand the changing technologies they will have to implement. The development of this knowledge is closely tied in with the training of our cadets, who took active part in the workshop days, as can be seen on the Ecoles de Saint-Cyr Coëtquidan website: http://www.st-cyr.terre.defense.gouv.fr/.

We offer this work to our English-speaking colleagues in the hope that it will make a modest contribution, by the exchanges it could spark, to better reciprocate knowledge and to reinforce comprehension and cohesion among the allied forces working together in the main theaters of operation.

Brigadier General Antoine Windeck
Commander
Ecoles de Saint-Cyr Coëtquidan

List of Contributors

Gérard de Boisboissel

Research Engineer at the Research Center of the French Military Academy of Saint-Cyr (CREC Saint-Cyr).

Didier Danet

Associate Professor of Management, head of the Global Action and Land Forces Department at the Research Center of the French Military Academy of Saint-Cyr (CREC Saint-Cyr).

Thierry Daups

Associate Professor of Public Law, University of Rennes 1; associated researcher at the Research Center of the French Military Academy of Saint-Cyr (CREC Saint-Cyr)

Ronan Doaré

Associate Professor of Public Law, Director of the Research Center of the French Military Academy of Saint-Cyr (CREC Saint-Cyr).

Éric Germain

Ph.D., Policy Advisor in charge of "Ethical, Religious & Societal issues" at the Directorate for Strategic Affairs (DAS).

Captain (USN Ret.) Mark R. Hagerott

Deputy Director, US Naval Academy Center for Cyber Security Studies and Distinguished Professor of Cyber Operations and Policy.

Jean-Paul Hanon

Senior Lecturer at the Research Center of the French Army Academy of Saint-Cyr (CREC Saint-Cyr); lecturer at Sciences-Po Paris.

Dominique Lambert

Ph.D. in Theoretical Physics and Ph.D in Philosophy. Professor at the University of Namur and member of the Belgian Royal Academy.

Georges Lucas

Class of 1984 Chair of Ethics, US Naval Academy and Professor of Ethics and Public Policy, Naval Postgraduate School

Christian Malis

Adjunct Professor of Strategic Studies at the Saint-Cyr Military Academy.

Colonel Eric Ozanne

Plan and future capabilities office, officer in charge of dismounted combat (2009-2012), French Army Staff. Commanding officer of the Second Infantry Regiment of the French Foreign Legion (since 2012).

Eric Pomes

Associate researcher at the Research Center of the French Military Academy of Saint-Cyr (CREC Saint-Cyr).

Colonel (USMC Ret.) E.W. Powers

Ph.D. Research Fellow, Potomac Institute for Policy Studies Center for Emerging Threats and Opportunities, Marine Corps Warfighting Lab, Quantico, Virginia.

Colonel Eugene K. Ressler

Head, Department of Electrical Engineering & Computer Science, U.S. Military Academy, West Point, New York.

Brigadier General Benoit Royal

Sub-directorate general in charge of the recruitment in the Army (Army Human Resources Directorate, 2010-2013). Army Information and Communication Branch Head (Army IC BH) and Public Affairs Advisor (PAA) of the Chief of Army Staff (2007-2010).

Noël Sharkey

Professor of Artificial Intelligence and Robotics and Professor of Public Engagement, University of Sheffield.

Colonel Barry L. Shoop

Deputy Department Head, Department of Electrical Engineering and Computer Science, U.S. Military Academy, West Point, New York.

Colonel Alexandr Štefek

Head of AD Systems Department, Faculty of Military Technology, University of Defence, Czech Republic.

Antonin Tisseron

Ph.D. in History, Independent Consultant and Research Fellow at the Research Center of the French Military Academy of Saint-Cyr (CREC Saint-Cyr).

Serge Tisseron

Psychiatrist, psychoanalyst, HDR Doctor of Psychology at the University Paris Ouest.

Dominique Vermersch

Professor of Ethics & Economics and Public policy at Agrocampus Ouest, Angers, France.

General Jean-Philippe Wirth

Member of the Conseil Scientifique de la Défense, French expert comittee advising the ministry of Defense on armament and Defense issues, former Deputy Chief of Staff, Studies-Plans-Finances on the Army Staff.

Major General Michel Yakovleff

Deputy Chief of Staff Plans at Joint Force Command, Brunssum.

Contents *page*

Contents

page

Figures

page

Figures *page*

Chapter 1 Introduction
Digitization and Robotization of the Battlefield: Evolution or Robolution?
by Didier Danet and Jean-Paul Hanon

When historians turn their gaze on the questions of defense in this first half of the 21st Century, they will observe that military robots brought in something brand new to the world of warfare, constituting an even more radical game-changer than the invention of nuclear weapons, since this not only affects the constantly changing modalities of warfare (HOW to wage war) but also its basic essence (WHO wages war). Such is, in substance, the message conveyed in the book *Wired for War* written by Brookings Institution researcher, Peter Singer.[1]

In support of the "robotics revolution" hypothesis, it is true that unmanned systems have undergone spectacular development in the Iraqi and Afghan theaters of operation.[2] Taking this observation as a basis, and drawing on several laws of industrial evolution (Moore's Law for the per-formance of machines, and the law of economies of scale with regard to their costs), Peter Singer and those sharing his views forecast the rapid generalization not only of robots but also of robotic systems operating in "packs," and capable of standing in for soldiers when conducting military operations involving the use of force.[3] They deduce from this the inevitability of battlefield robotization and the need for military and civilian commanders to show that they are up to the challenge by committing wholeheartedly to the process, which presupposes, in particular, addressing here and now the questions inherent in the opening of such a Pandora's Box.[4]

To sum up this theory in brief, it culminates in two fundamental conclusions:

1. Robotization is an inevitable and irreversible process; it is already underway and is as yet only in its infancy;
2. Robotization poses radical new questions that need to be addressed today in order to construct the intellectual framework required for mastering all this technological innovation.[5]

Yet when considered more closely, the theory of the robotics revolution, however seductive it may seem, does raise a certain number of questions.

First of all, does the deployment of these "Predators," "Packbots" and the like really constitute such a radical technological game-changer, so exceptional in the history of warfare to the point that we may talk categorically in terms of a technical, scientific and military revolution? It seems to us that the theory of a radical game-changer, with robots at its center, needs to be put into perspective, for two reasons. On the one hand, robotics is less a scientific revolution than a cross between disciplines that are already quite familiar: mechanics, electronics and telecommunications, IT and artificial intelligence, in particular.[6] To the extent that it is possible to quantify the import of discoveries, inventions and innovations, robotization seems less revolutionary than, for example, the discovery of nuclear power and the effective use of the atom bomb in World War II. According to Kuhn, military robotics is clearly about "normal science" and not "revolutionary science." In no way does it call into question paradigms commonly assumed by the scientific community, this being a precondition of a genuine scientific revolution, but rather it comes across as a combination or synthesis of the respective advances of these paradigms. Secondly, even if robots do constitute a revolution in terms of their media visibility, the robotization of the battlefield is already a long-established military reality.[7] The capability of deploying remote-controlled or programmed devices to carry out a given mission dates back, at the very least, to the Second World War (remote-controlled German (Goliath) or Soviet (TT26) tanks, for example), and ground forces have long been using robots for mine-clearance operations. When taking a step back in order to contemplate whether or not robotization is genuinely revolutionary, it is no doubt possible to conclude, as does Robert Ranquet, that the history of weaponry has known phases of innovation more radical than those at the end of the 20th Century.[8]

It is then possible to ask oneself if the robotization argument, as put forward by Peter Singer, is not simply yet another embodiment of the "technologist temptation" which, without being exclusive to the United States, often takes form more vigorously there than elsewhere? Rightly denounced by General Vincent Desportes, the "technologist temptation" serves to "express the rationality specific to the US military-industrial complex, inciting it to pursue the profitable channels of high-tech weaponry and lobbying in favor of incessantly growing budgets so as to finance ever more expensive equipment."[9] It would no doubt be specious to boil down the development of robotized systems to a simple matter of acquiring public money by means of a coalition of agents searching for public subsidies likely to boost the dividends of their shareholders. Conversely, it would also be wrong to ignore the fact that the robotization of the battlefield represents a major economic and financial issue that serves as a focus for specific visions and interests which are not entirely compatible and which presuppose a series of arbitrations, the challenges and consequences of which are decisive for the activity and for the profits of manufacturers in the sector. The massive use of drones therefore appears to be broadly inseparable from the movement towards defense privatization initiated in the United States. Private stake-holders control part of this, in a way that is without precedent in the history of armament. Whether it is a matter, in the traditional way, of the design, production and maintenance of weapons systems or, in more original fashion, of their deployment and all services arising from (or associated with) weapons use, private companies are everywhere. What is on offer is so comprehensive that, if the political leaders were so to decide, the US Army might no longer own the equipment deployed by the military but could be a consumer of services entirely produced and controlled by external service providers: time spent on observation and surveillance, analysis of data and production of information, even the capacity to intervene and destroy. Presenting the general robotization of the Armed Forces as their only possible means of development in order to ensure their efficiency tends to echo rather too much the discourse regarding outsourcing not to appear as a troubling sign of a conception of defense activities largely anchored to military industry. Blindly adhering to this view means first, exposing oneself to the observation so often made in history that technological superiority is by no means synonymous with assured victory, and that all progress engenders its own contradictions and is bound up within its own limits (Augustine Law, limits of total technology,[10] reaction of inventive adversaries,[11] etc.). It means also going down the political, strategic, economic and budgetary dead ends of contractual commitment, so clearly illustrated today by the lessons learned from Iraq and Afghanistan.[12]

Last of all, are we not seeing, in the literature dedicated to drones (UAVs) or ground robots (UGVs), the projection of the science-fiction imagination onto the realities of contemporary conflict situations? The use of robots in Iraq and Afghanistan is grist for the mill of a discourse that is powerfully conditioned by SF literature, science fiction films and video games, thereby opening the path to questioning the very essence of warfare and the dehumanization of the use of force.[13] As things stand, the reality on the ground is more banal. The robot, particularly the ground robot, constitutes far more an appendix to the soldier's eye and arm than it does an autonomous decision-making and attack system. Operations recently conducted in Afghanistan clearly demonstrate that, despite the growing number of robots deployed by military forces, the fundamental characteristics of warfare continue to prevail despite the growing use of remote-control devices.[14] As well as this first type of risk, it seems to us that there is another: that of a dearth of insight with regard to robotization. It is commonplace in military history or, indeed, in industrial history more generally, for the inventor of a technology not to be necessarily the best placed to explore it or exploit all its possibilities with a view to making best use of it. To take just the commonly cited example of the battle tank, the Germans showed themselves to be far superior to the French and the British in the use that could be made of a military tool which they had not themselves invented. By focusing on approaches formatted by models that are very largely imitative (imitating man, imitating nature) or else strongly inspired by the literature of science-fiction, military thought revolves around the terms of the problem and ignores the strategic or tactical data which could drive the design and deployment of robots on the battlefield.

By dint of these lines of enquiry, the question arising is that of the agenda of thoughts on military robots. Robotization incontestably deserves to be included in this agenda, as has already been the case for a long time now with regard to the engineering sciences. As far as the human, social and political sciences are concerned, the frequent tendency of scientists to focus their attention on a very advanced type of robot, equipped with artificial intelligence that endows it with extensive autonomy of action, makes the most spectacular and most futuristic form of robotization the center of gravity for reflections in this regard. This gives rise to widespread ignorance of the factors likely to call into question, limit or hold back the development of robots in military forces, along with basic questions relating to their end purpose, their use or their expected characteristics.

The purpose of the argument that follows is to propose a framework for the problems that robotization will throw up tomorrow, along with the questions that it raises today, particularly in terms of the change management that would be required in the event of any generalized use of this particular technical asset: the military robot. Naturally, there is no contradiction inherent in this twin line of questioning, nor does it call into greater question the relevance of validity of the studies carried out previously. With regard to the debates regarding the theories presented, the problems highlighted may seem here to be transient or secondary. The scant interest that they have generated among specialists may then be explained by the traditional adage: *"De minimis non curat praetor."* (Authority does not concern itself with trifles) Nevertheless, outside of the United States, where the volume of the budgets dedicated to defense is such that the risk of investment errors is not prohibitive, the size of the challenges and the weight of budgetary constraints impose extra levels of prudence and increased attention with regard to the management of the envisaged change.

Questions for Today

The questions being asked today about military robots relate globally to the problem of management in an organization faced with substantial technological innovation. Technological developments make it possible to envisage the production of remotely controlled machines, or machines endowed with a certain degree of autonomy for carrying out tasks involved in the realization of the missions of military forces. These machines are extremely diverse with regard to their usages, their capabilities, their technical characteristics, their degree of autonomy and their cost.[15] The first question to be asked is therefore just what precisely is the definition of the military robot? Beyond that, if we consider that there is no technological inevitability and that the various military forces are not unavoidably driven to the generalized robotization of their equipment, then the deployment of military robots must be considered to be an investment choice which presupposes a favorable cost-benefit analysis and a strategic change process, the conducting of which needs to take into account the inherent constraints of any process of this type.

The Uncertain Definition of the Military Robot

The term “robot” is likely to designate a set of individual machines or machine systems that are highly diverse from the point of view of their constituent elements, their capacities, their func-tions, their degree of autonomy or the nature of the missions in which they may be deployed. The field of enquiry is therefore very broad, and research suffers from the fact that there is no conventional definition for robots. Certain barriers seem at the very least debatable, even arbitrary. The fact, for example, of excluding missiles as a category from the discussion on robots is based far more on an argument of authority with a view to simplifying the handling of the issue than the fruit of indisputable objective classification. Each study is therefore likely to produce its own conceptual framework. Generally speaking, a military robot is most frequently defined as a system:

1. Possessing capacities of perception, communication, decision-making and action;
2. Supervised by human combatants or acting autonomously according to pre-set behavioral rules;
3. Capable of improving its own performance through automatic learning.

From a more pragmatic perspective, Lin et al. focus on decision-making autonomy and the capacity of the machine to find things out, make decisions and take action: “A powered machine that (1) senses, (2) thinks (in a deliberative, non-mechanical sense), and (3) acts.”[16] From a highly operational perspective, the robot is sometimes perceived as a remote-controlled machine or one equipped with a certain decision-making autonomy, and capable of returning to its starting point once the mission is complete. All of these definitions, the most complex of which are no doubt the least usable, have one point in common, which is the truly distinctive criterion of the robot compared to other machines, i.ethe degree of autonomy vis-à-vis human beings.

The categorization of robots is hardly any more precise. There exists no universally accepted typology, and an analysis of the bibliography brings to light multiple classifications of different types: technical classifications (in particular, based on the size of the robotic platforms), functional classifications or operational classifications (according to the missions or tasks of robots). All characterizations insist on two of the fundamental dimensions of battlefield robotization: the degree of autonomy of the robot and the more or less imminent prospect of seeing robots act in groups, whether these groups are based on redundancy (in order to take account of the possible risk of some of them being destroyed) or on complementarity (with a view to operations presupposing a combination or recombination of machine capabilities). The robot should therefore be envisaged as an autonomous machine or as a system of machines.

The Cost-Benefit Analysis

The deployment of robots in the Armed Forces can be analyzed as a change in the current balance of the productive combination of the institution, i.e. in the composition of the resources made available for the action of military forces. The relative proportion of technological capital increases as the proportion of labor capital is reduced; in other words, man is freed from certain tasks which are assigned to the machine. In this regard, the possible deployment of robots involves considering the general logic of any equipment program aiming to substitute one factor with another. The analysis must enable an assessment to be made from the perspective of the ratio of costs to benefits. Yet the very diversity of the possible applications prevents any global judgement from being made of the robotization phenomenon.

Of course, it is possible to identify a general logic at work behind the large-scale deployment of many robots that industry proposes for military forces: enabling human resources (rare, highly-trained, expensive, etc.) to focus on tasks where they provide specific added value (the famous "core business") and relieving them of peripheral activities that may be delegated to a machine (the robot) just as they may be, in similar fashion, to a third party (employees of private military companies). With technological progress enabling the increased substitution of capital for labor, those in charge of the institution are led to query the pertinence of this kind of substitution. For it to be justified, the robot must demonstrate, *at the very least,* its capability to preserve and make best use of the human resources so that the latter's potential can be fully leveraged in missions where it is irreplaceable. This may, for example, involve the robot exploring an inaccessible environment or one presenting a significant risk (contaminated zones, urban or mountainous zones, for example) or keeping specialists away from danger when the intervention can be done from a distance (neutralizing an explosive device, driving an exposed vehicle). The use of a robot is also justified when this prevents the attrition of potential through daily tasks that the machine can carry out better than people could do, since it is not susceptible to fatigue, boredom or distraction (surveillance of infrastructure or geographical area, for example). Lastly, the deployment of robots is justified once again when it helps to boost human capacities, such as in terms of mobility, load capacity, perception of the environment, etc. In this way the robot offers savings to the Armed Forces and partially relieves them of the constraints that the limits arising from human nature or the scarcity of human resources impose on their freedom of action. Beyond this immediate approach, we should envisage the consequences of robotization on the efficiency of action of the military force, a question to which we shall return when considering the conditions of acceptability of the robot in military units.

Faced with these benefits, the principle of which is clearly perceptible even if the modes of assessment are somewhat complex to establish, there are many requirements to be taken into account, in particular those relating to the cost and deployment of the robot in this particular environment—the battlefield.[17]

It must first and foremost be as simple as possible to use. Deployed by military personnel in highly stressful situations, it must be possible to use the ground robot without the need for engineers or specialists (maintenance, IT, analysts, etc.), who will be absent from the battlefield. Likewise, since the robot is meant to be an aid to the soldier, it should not slow down maneuvers on account, for example, of its dimensions, its complex deployment or insufficient mobility.[18] By the same token, the use of the robot should not require any additional physical effort or particular attention on the part of the soldier. Of a weight such that it can be easily added to the existing equipment and transported by the units on the ground, it must be possible to "start it up and forget about it."

The robot must also be robust and sturdy, since it is meant to be used in hostile environments where the precise idea is to save the human resources from being overexposed. The robot must therefore work in extreme conditions (heat, dust, humidity, contamination, etc.), and the high rate of attrition that it is logically expected to undergo must not cause any problems in terms of cost.[19]

This quick sketch of the end purpose and environment of the ground robot generates an image that is considerably at variance with the notion of the Terminator, a sophisticated and autonomous machine that is capable of replacing the soldier in the use of force. The robot that we are talking about today is more of a simple and workmanlike tool, relatively inexpensive, easily transportable and which helps to safeguard combatants by intervening in inaccessible or dangerous areas and relieving them of physical or psychological burdens which diminish the potential of the human resource.

Undeniable progress has been made by the designers and manufacturers of military ground robots. The fact however remains that the devices presented to date do not correspond entirely to the notion of the ideal robot as has been sketched out here. It is therefore not surprising that, with budgets being squeezed, the armed forces of countries other than the United States seem somewhat reluctant to embark on massive battlefield robotization programs if these are to follow the usual logic of weapons programs: long design-manufacturing processes, complex technical specifications, systematic tightening up of procedures, high costs, limited numbers, etc.[20]

The Change Management Process

By postulating the inevitable character of battlefield robotization and prioritizing questions predicated on a quasi-science-fiction context, we are led to understand that the robot is the future of the Armed Forces and that any delay in the robotization process may be detrimental to the efficiency of these forces.

Yet even if we suppose that technological progress and the innovation capabilities of the designers and manufacturers of robots make it possible to align the properties of these robots with the expectations of military forces, the fact nonetheless remains that the robotization of the battlefield is a process of transformation which presupposes being taken into account and conducted according to the principles, constraints and methods applicable to any strategic change within an organization.[21]

In the particular case of robotization, the strategic change is no minor matter. Its promoters flag it as both radical and urgent. On the one hand, the generalization of the robot is presented as an inevitable process, the rapid speed of which is dictated by the incessant advances in robotics technology. On the other, it involves a profound transformation of the structures of the organization, its modes of operation, its values and its institutional culture. This concerns in particular the place of the soldier on the battlefield, his relation to the enemy, to the other members of his unit and to his commanders, and to the population within which the military operations take place.

Faced with a transformation of such dimensions, many questions remain to be answered. Does the military institution have the budgetary, human and material resources required for the implementation of such a change? Is it ready to take on board the cultural, doctrinal and organizational upheaval that a robotics revolution would be sure to generate? Are the budgetary implications a prohibitive constraint or a means of excluding *a priori* questioning? Are the stakeholders all convinced of the pertinence of the change and of the efficiency of robotized solutions for the actions of the terrestrial armed forces? Are they structured so as to be able to manage the robotization process in such a way as to maintain a global perspective?[22] Having already embarked on numerous processes of technical or organizational innovation that may be qualified as "operational," can the military institution easily envisage the implementation of the ambidextrous structures required for managing an innovation that is presented as being radical ("exploratory innovation")?[23]

All told, as current technological advances stand and for the countries whose defense resources are subject to major economy drives, robotization is by no means a given. Even if certain characteristics of robots are clearly attractive, in particular for preserving the human capital of military forces, the cost-benefit analysis would itself benefit from more profound investigation and, in the event of it making yet more apparent the advantages of robotization, a proactive change management process should be implemented.

Questions For Tomorrow

The questions for tomorrow are those which result from the possible presence on the battlefield of autonomous robots endowed with artificial intelligence allowing them to make decisions on the basis of preset rules and for which recourse to force is part of their assignment. It is in this framework that the debates concerning the human essence of warfare and its legal-ethical corollary are conducted.

Robotization and the Essence of Warfare

The hypothesis often put forward is that the generalization of robots modifies the nature of warfare by substantially altering the decision-making chain which culminates in the use of force against an enemy. According to this theory, the introduction of robots onto the battlefield not only alters the modalities of military action (HOW war is waged) but, more profoundly, the nature of the combatants, and therefore of the combat (WHO wages war). According to the "Singer" theory, technological progress with weaponry (from the crossbow to the atom bomb) has until now only increased the action capability of the combatant, but has not called into question the combatant's place in the decision-making system. He could move more quickly, strike harder and further, protect himself better from the blows of the adversary, process increasing quantities of data, etc. Yet he remained at all times master and commander of his decisions and his actions. The effect of robotization, if not its object, would be to hand over all or part of this capacity to choose to a machine endowed with a corpus of preset action rules, and which it would implement autono-mously. This would give rise to a profound transformation of the decision and leadership process, of the legal notion of the combatant and of the liability regime applicable in the event of damages caused by the improper actions of one of these robots.[24] Likewise, the ethical principles that applied in the framework of a conflict opposing human combatants would be lost if machines were to take their place. It would therefore be necessary to reconstruct a new set of ethics designed to govern the rules of action covering the behavior of military robots.[25]

It would be presumptuous to attempt to answer such a complex question in just a few lines.[26] It is nevertheless possible to point out that, here again, the transformation is not perhaps as radical as it might seem at first sightIt should first of all be underlined that robotization does not necessarily lead to the loss of human control over operations. Contrary to what the "Singer theory" may postulate, the history of military robots is not that of an increasing exclusion of man from the decision-making loop. Weapons development does not follow a linear progression leading from the tool manipulated by man through the remotely controlled machine to the independent robot driven by artificial intelligence. Paradoxically, total machine autonomy seems to be more tolerated than aspired to, and to manifest not technological progress but the incapacity to procure the precise mechanisms that you need. The missions assigned to the first drones were therefore totally automated due to the lack of sufficiently powerful telecommunication tools to allow those controlling them the possibility of modifying the flight plan as the mission pro-gressed. In the case of a totally automated UAV, the machine cannot overfly a sector whose interest has not been anticipated or, conversely, cut short a mission which proves to be of less interest than was foreseen. Here, progress has consisted precisely in reintroducing the human being into the decision-making loop as soon as the available technology so allowed, thereby reducing the contribution of the artificial intelligence to the running of the mission. The same applies for ground robots, with the robot becoming autonomous when transmission between operator and machine becomes impossible, on account of physical obstacles for example.[27]

The autonomy of the machine should not therefore be simply envisaged as the culmination of technological reasoning that would lead to its inevitable extension.[28] The result of this is that, in ethical and legal terms, certain balances or certain traditional distinctions may be modified through the intervention of robots, as indeed they may be in the wake of the involvement of employees from private military companies in the theaters of operation.[29] Yet, *de facto* (and, probably, *de jure*), the State could not disclaim responsibility for equipment that it directly implements through the medium of its armed forces[30] or, indirectly, through that of companies from which it purchases equipment, or to which it contractually delegates certain missions.[31] This responsibility should govern the questions of accountability for the damages caused by robotization, if not their actual effectiveness.

Robotization and Conflict Management

Even if the extent of the impact of robotization on the essence of warfare is subject to discussion and debate, it is nonetheless incontestable that it changes some of the key ways in which military conflict is conducted. Without going into detail about these modifications, each of which could be subject to a program of research and study, it is possible to observe that robotization exercises an influence both in macroscopic terms with regard to power relations and the types of conflict and in the more microscopic terms of the conditions of terrestrial military action.[32]

The Risk of the Depolitization of Conflicts

What we call here the depolitization of conflicts refers to the deliberate intention of States, which are capable of so doing, to euphemize, politically and legally, the political, moral and media consequences of the conflict. If we consider that a robot is defined by its degree of autonomy vis-à-vis humans, and that it works moreover within a system which itself takes its place within automated scenarios, it is possible to claim that robotization necessarily involves placing the traditional chain of management, up to the highest level, at arm's length. The collateral damage caused by automated UAV fire in Afghanistan is one of the illustrations of this euphemism. The fact is, moreover, that the moral and political responsibility for them has never been shouldered by national governments. Technical error has been the sole argument to explain and justify the destruction of civilian populations.

Beyond this technical aspect, there is a real interest and therefore a real desire for States to deploy robots on the battlefield inasmuch as this deployment signifies fewer human losses, in particular in countries such as the USA or Israel where these human losses are an essential criterion in the political success of military operations and the vital support likely to be provided in the form of public opinion. Robotization is envisaged by some as bringing with it a relaxation of the legal constraints born of the contemporary laws governing armed conflicts. According to them, States conducting military operations would no longer bear the same degree of legal responsibility, since all the international principles and rules, both written and unwritten, governing the laws of armed conflicts are said to be intrinsically linked to the essentially human nature of these conflicts and would be inapplicable once operations were being conducted by robots. We have seen that this extreme position is probably ill-founded. However, be that as it may, questions arising from robotization remain. What, in the future, will be the impact of the use of robots on the fundamental concepts and principles of the laws of armed conflicts? Could robots be accredited with a legal personality, and brought under the umbrella of a legal system that recognised the personality of autonomous decision-making objects? Will the robot remain a complex machine involving a chain of responsibility that includes its designers as well as its users? This field of study remains very much open to exploration.

Neutralization of Conflicts

The robotization of the battlefield will offer a new range of strategic options for the deployment of military power. These options may be decisive with regard to preventing and neutralising conflicts. The large-scale deployment of robots in potential high risk zones (ethnic tensions, deployment of troops in border zones, loss of control of the territory by a State, etc.) would make available a vigilance and alert system which could lead to the rapid neutralisation of potential conflicts, something that the international community has found it difficult to do until now. This organised vigilance system would also make it possible to keep far more efficient track of peace agreements. Would this result in more significant involvement of the international organizations in low-intensity conflict situations? Would it be possible to deploy more rapidly and at least cost mechanisms designed to control tensions in a given zone? Would the world be safer if the prevention and treatment of conflicts were based on robot systems rather than the international forces that we are familiar with today?

Lastly, the deployment of these robots would also carry a far more serious threat for those disrupting the international system insofar as rogue states and the like would logically be subject to forms of robotic prohibition. Their frontiers, their air space and their territorial waters, even certain zones within their territory, would be occupied by "robotized phalanxes" giving physical form to a permanent threat which completes the "spatial inquisition" already at work.[33]

Modifying Power Relations

By affecting military forces and the conditions for exercising offensive and defensive power, technical progress can cause considerable changes to the balance of power, as well as a reorganization of the strategic landscape.In this regard, there can hardly be any doubt that the robotization process will call into question the current classification and typology of the military powers. Taking account of the diversity of the foreseeable applications and the relatively widespread distribution of the necessary skills, it is possible to anticipate a relative dispersal of the production and use of military robots, with certain countries continuing to manage complex technologies and the most sophisticated robots while others may adopt "low-cost" robots, the workmanlike nature of which would not be to the detriment of their efficiency, especially if they were used in an innovative fashion in the framework of irregular conflicts.

This new arms age will herald a reshuffling of the pecking order in the technical-industrial world. On the one hand, it will modify the relations between the various branches contributing to the production of weapons systems. On the other, it will lead to a redistribution of the economic power between the traditionally dominant countries (USA, Europe, Russia, etc.) and the emerging nations which master the technologies of automation, miniaturization and IT.[34] Certain countries or certain regions may profit from this reshuffle by offering fertile ground to the implementation of a new type of "armament clusters," constructed in particular around dual technologies, the combination of which forms the basis of military robot manufacturing (telecommunications, IT, electronics, artificial intelligence, materials, mechanics, etc.). Internally, the possible redistribution of power between the industrial branches that contribute to the production of weapons systems raises the following questions in particular:

1. Can we apply to ground robots the notion of "generation," such as it is recognized in the high-tech industries; with what effects in terms of capacities and costs; and with what degree of anticipation?

2. What is the reality of the supposed duality between civil robotics technologies and those required for military robotics? Will the production of military robots tend to comply with the economic laws applicable to the corresponding civil sectors (IT, telecommunications), characterized by major economies of scale and a rapid fall in production costs, or will it comply with the usual laws of the arms industry?
3. Will the cost of creating and operating robotized units be necessarily less than for the current units on account of the reduced human losses arising from the assignment to military robots of inherently dangerous tasks? Can the necessary investments in "the training of robots" (drafting operating scenarios, writing behavioral software, developing communication systems within the robotic systems and between robot and man, etc.) generate gains on account of the possible low-cost replication of the technical and software mechanisms?
4. What governance would it be suitable to implement in order to encourage articulation of the operational needs, political choices and industrial ambitions? Is a structure such as the DGA (French General Directorate for Armament) likely to be able to resolve the problems posed by the complex relations that commonly characterize the production of weapons systems?
5. How can the development of new defense robotics companies be encouraged in countries like France? What role can competitive clusters play in the development of the basic robot technologies and in the constitution of the technical-industrial networks required for the development of military robotics?

Internationally, is the robotization of the battlefield likely to substantially modify the hierarchy of the weapons systems producers? We know, for example, that the United States have an unquestionable lead in terms of navigation in open environments, robotics architecture and military robotics applications. On the other hand, Japan and Korea dominate with regard to issues of mobility and humanoid robots, while Europe for its part has a strong case to state in terms of mobility in structured environments (urban networks, for example). Countries such as Israel and Australia also have specific strengths in the field. Many stakeholders, be they State or non-State players, are capable of drawing on the panoply of existing technologies in order to design and deploy "low-cost" robots that are likely to enhance their action capability in the framework of asymmetric strategies. These countries are, in certain cases, already involved in traditional arms production; others are likely to take their seat at the table, thereby calling into question the status quo. What is the current map of development of the robotics industry around the world?

Who are the stakeholders and what are the major strategies? What are the needs and the budgets? What are the geopolitical issues? What new alliances are to be set up?

Here again, the field of studies to be implemented is vast.

The Place of Robots in the General Coercion System

Since the 1980s, the international scene has come up with a reshuffling of the main players involved in coercion. Under the effect of the globalization of exchanges, the lack of differentiation between internal security and external security and the emergence of doctrines centered on the control or protection of populations, the main countries of the West have operated a constant diminution of their military forces and, in parallel, increased police and private security forces. In this regard, the constant reduction of military numbers, alongside the fact that the success of the operations in which they are engaged is increasingly relative, demonstrates that States are looking to find an equation other than the generalized mobilization of military forces. This new equation, which is characterized by the increasing preponderance of police and intelligence system—in Germany, for example: the advent of agencies specialized in organized crime or illegal trafficking control—in the USA in particular, the increasing recourse to private military and security companies, the intervention of legal systems to prop up the root-and-branch changes to the law, has a new player: robots. The question is now to understand the place of robots within this recomposed field of the stakeholders involved in coercion.

A first assumption is that robotic systems are at the interface of two major trends:

1. The trend that puts the emphasis, strategically and politically, on the mass capacity for the protection and surveillance of individuals in a society that is increasingly fluid and where population control involves the control of movements of all types: goods, capital, individuals, information, etc.;
2. The trend which, in the name of general prevention, makes anticipation, speed of reaction and the least cost of intervention in all its dimensions the factors which tend to favor automated information collection and processing systems and the constitution of automated scenarios and profiles.

Robotized systems, since they combine all these criteria: collecting and processing information of all types, in particular police and military information, along with autonomy, efficiency and disengagement from the hierarchical structures, should ultimately constitute a preferred player in this search for continuity in the field of coercion. The question however remains open concerning the distribution of roles, practices and usages, and their impact on the societies concerned and on the system of international relations as a whole. It is this dimension which makes robotization and robotized systems an object of study which extends far beyond the framework of operational usage in the battlefield, and gives it its true scope.

Robotization and Conditions of Intervention of Military Forces

Lastly, robotization profoundly modifies the conditions of intervention of military forces. Even if the manufacturers of robots make special efforts with regard to the man-machine interface so that the robot is the "companion" of the soldier, the fact no less remains that the generalized use of robots on the battlefield will necessarily have effects of all kinds on the structures of military forces, the relations within units (robotization as a factor in developing the esprit de corps and leadership), the relations between the forces and the enemy (robotization as a manifestation of the ethnocentricity of developed countries) and the relations between military forces and local populations (robotization as a mechanism for the surveillance of areas and populations or as an impersonal weapon of destruction).[35]

Technological progress makes it possible to envisage multiple applications for military robots: reconnaissance, mine clearance, observation and surveillance, medical evacuation, acquisition and destruction of targets, etc. The only apparent limits to robotization would seem to pertain to the breadth of imagination of robot designers and the priorities set by those responsible for making the military or industrial choices. Nevertheless, envisaging battlefield robotization according to the sole criterion of technical feasibility and production capacities would mean neglecting, even ignoring, the man-machine interface and all that is most subtle and problematic in that regard.

Three factors therefore appear essential: the degree of autonomy of robots in the phases of combat, the impact of robotization on the population, and the relationship with the enemy.

The Degree of Autonomy of Robots in the Phases of Combat

As has already been previously pointed out, any definition of a robot or of a system of robots poses the general question of its degree of autonomy vis-à-vis the combatant and its integration within a human system. How to define the degree of autonomy assigned to robots? The robotization of the battlefield involves establishing detailed scenarios of combat situations and defining standardised behavior suited to the action to be carried out and respectful of the laws concerning armed conflicts and military ethics.[36] The result of this is that the behavior of the robot must be determined by a set of behavioral rules that need to be formulated.

This then gives rise to the question of knowing who is responsible for the doctrine of robot use in the field, for the formulation of the behavioral rules, for the architecture of the decision-making processes, and for the margin of autonomy granted to the robot, ranging from para-human artificial intelligence to hyper-human artificial intelligence.[37] Will the latter go so far as to enable the robot to eliminate an enemy or destroy a target without the intervention of a human decision-making echelon? Does a robot need to be programmed for it to evaluate the received orders and refuse to execute an order when it is illegal? To whom is a robot accountable for its actions? Who can decide to interrupt the action of a robot? Does the chain of command not risk being undermined by the possibility offered to political or military decision-makers to control the robot themselves, in other words to intervene directly in the conduct of operations on the ground? Is it not necessary to guard against this risk by installing, for example, mechanisms for the acknowledgement and systematic recording of the interventions requested of robots?

Even if the actual robot has decision-making autonomy to a greater or lesser degree, the fact nonetheless remains that it operates alongside the men making up the military force. Its presence significantly modifies the practice of leadership, the formation of an *esprit de corps,* even the very notion of the combatant. It almost inevitably involves a modification of the manner in which ground operations are conceived and conducted.

With regard to the practice of leadership, if robotization is analyzed as the total or partial replacement of the individual by the machine, the commanded units will evolve towards a lesser human density, in terms both quantitative (ratio of men to the forces as a whole) and qualitative (the handling of increasingly complex missions by increasingly qualified robots). Leadership will be exercised on human/machine systems or even, in the medium term, on machine systems alone. The nature of leadership, the aptitudes required to exercise it, indeed, the very notion of "leadership" seem likely to evolve considerably.

In this way, the question of the relations between combatants and non-combatants is raised anew by the robotization of the battlefield. In an armed conflict situation, international laws stipulate the application of written and unwritten rules, valid with regard to both international and non-international conflicts, and the purpose of which is to protect persons who are not or who are no longer participating in combat, on the one hand, and to limit the methods and means of combat, on the other. In this context, international humanitarian law is based on a founding categorization of the stakeholders (combatants, non-combatants, war victims, civilian population) and the principles (of proportionality and discrimination). As such, these principles, which are already challenged in the event of contemporary irregular conflicts, will be all the more so with the arrival of robots on the battlefield. What becomes of the combatant/noncombatant distinction when the data gathered by the robot are analyzed by an employee of a civil company, and the robot is remotely controlled by an employee of a private military company who may or may not be present on the battlefield? Do robots form part of the dichotomy between military objectives and civil property? What sense can the notion of "direct participation in hostilities" take in the respective hypotheses of the robot being under the control of a soldier or else an engineer?

By the same token, robotization would have to incorporate as a direct consequence the distancing, disassociation even, of combatants from the same unit; a physical remoteness characterized by the distance between the person operating the remote controls (or who is responsible for this) and a psychological remoteness which raises the more general question of the levels of cohesion to be obtained between men and machines. Taking the assumption of highly robotized units, is the presence of machines, endowed with a certain decision-making autonomy, free of consequences with regard to the social relations within the group, or does it bring with it the risk of generating changes to the collective behavior? What becomes of the *esprit de corps* which constitutes the cornerstone of military units if the robot becomes an increasingly present "brother in arms"?

Robotization also brings with it consequences with regard to military tactics. Technical progress makes it possible to equip military units with machines capable of informing them, tackling explosive devices, supplying them, providing them with medical care, etc. The possibilities opened up by this are not just likely to amplify existing capabilities, with their conditions of implementation remaining unchanged. They are sure to give rise to the generation of new frameworks of use, new forms of tactical action, new procedures. There is a great risk in this area of "making new out of old," in other words, conceiving robotization based on pre-existing categories and routines, and not opening up the field of possibilities offered by the advent of robots in order to conceive new tactical approaches. History shows that in every age the inventors of new technologies are not necessarily those who have been able to make best use of them on the battlefield.

Lastly, robotization and the automation of combat sequences presuppose the conceiving and drafting of complex scenarios corresponding to typical combat sequences which may, quite possibly, be integrated in their turn as part of wider-ranging procedures. Conceiving the interplay between men and machines is all about fitting this interplay into larger-scale automated systems. What might these typical combat sequences therefore be? With respect to what adversary? Do they need to be categorized hierarchically or sequentially? Do they rehash the questions of simulation and wargaming? Who bears general responsibility for software architectures of this type? What is likely to be the place of the inevitable software emanating from the civilian sector in the robotized system? Do military robots need to be kept entirely free of such software (at the risk of having to address problems of cost, transparency and maintenance), or should they integrate certain civil software packages (involving creation of significant dependence on a given specialized company)? Does the integration of these sequences into preset scenarios lead to the definition of profiles for adversaries and hostile actions? In this case, the use of this type of construction is inseparable from the notion of prevention.

Robotization and Relations with the Population

Robotization runs counter to the central idea of current doctrines of warfare within populations, since it is hard to see how the massive use of robots would make it possible to create the indispensable social link for "winning over hearts and minds." The robotization of the battlefield and, beyond that, the entire theater of operations (intelligence, surveillance, support, destruction, etc.) is likely to engender reactions of distrust, even hostility, on the part of a population whom robots have been assigned to observe, monitor, record, control, and so on. The absence of human sentiment may be considered an advantage on the battlefield insofar as it eliminates the risk of deviant behavior driven by hatred, vengeance or fear. On the other hand, it constitutes a major handicap when it comes to reconciling military forces with the population.

Robotization and the Relationship with the Enemy

Western military forces will not have the monopoly of robots on the battlefield. It is reasonable to assume, indeed, that the use of technologies characterised by economies of scale and gains in productivity will make it possible to bring down rapidly the cost of producing these robots. The result of this is that many parties, whether regular forces or not, may acquire them and control how they are used. Furthermore, it is not inconceivable that robots might be captured and reprogrammed by specialists, whose skills seem to be fairly widespread worldwide.[38] Lastly, and above all, even if robotization is envisaged in the developed countries as a form of advanced technology, it is quite possible to conceive of a robotization based on simple techniques (remote control, for example), but which is thoroughly efficient. An evident parallel may therefore be drawn with the manufacturing and use of improvised explosive devices on all contemporary battlefields. Western forces must therefore prepare themselves for "hybrid" forms of combat where the enemy will also be capable of implementing robotic systems which may be less sophisticated but the use of which may correspond to unusual tactical scenarios.

The use of robots for carrying out high-risk missions, increasing the destructive capability or monitoring populations addresses, for their Western users, a certain rationality and logic of minimizing human losses, something that is now axiomatic. This rationality should not obscure the fact, however, that for most nations at war—Israel and the United States in particular—the priority is to save the lives of their own people, whatever may be the price to pay for the adversary and, possibly, the civilian populations in combat zones. In other words, the enemy who has to fight a robotized army most certainly does not have the same perception of the situation. There is therefore a high chance that the enemy gets an even stronger feeling that he is fighting against adversaries who once again possess technological supremacy, faced with which he is sure to be defeated. If this theory proved to be true, the robotization of the battlefield would therefore act as an accelerator of asymmetric combat in its most extreme and unexpected forms; it could then serve to reinforce the "normal," justified and efficient character of certain modes of action that we today judge to be irregular:guerrilla tactics, terrorism, suicide attacks, IT attacks, etc.

Conclusion

More than a complete revolution in military technology and strategic thinking, the robotization of the battlefield seems to us rather to constitute a major evolution, all the more fascinating a topic of study inasmuch as, if we discount the idea of "inevitable technological fate," i.e. an inevitable development to which military forces would be obliged to submit without the power of any control over it, those who turn their minds to the questions of defense or else who assume responsibility for it find themselves faced with essential questions.

Questions about the desired degree of robotization of a military force, the rate of development of this robotization, the missions for which robots may be used appropriately, the degree of autonomy assigned to them, the type of use that can be made of them, the politico-strategic consequences for conflict management, and so on. Some of these questions fall within the scope of the relatively classic concerns of the human, social and political sciences, while others mark a new departure.

The way that we see it, and contrary to the analyses that are often proposed, robotization does not seem to radically transform the essence of warfare, which remains above all a human phenomenon, motivated by a clash of wills. However, it is likely to affect profoundly the ways in which conflicts are prosecuted, whether in terms of the balance of power that it risks disrupting, the renewed importance that it may confer on conflict prevention policies or the relations that prevail within and between groups of humans present on the battlefield.

In this regard, for us it seems vital that research is carried out in order to address the questions arising today, and in particular the cost-benefit analysis for guiding investment choices without falling victim to the "technologist illusion" or postulating that the budgetary constraints are insurmountable. This attachment to considerations which are relatively traditional, and which trivialize somewhat the robotization process, should not imply any renouncement of the study of the questions for tomorrow: those linked to the hypothesis of military robots endowed with a large degree of autonomy and technically capable of using force on the basis of preset rules. Whatever the case, it would be wise not to underestimate the capacity for the former to hold back developments if they are ignored, and not to overestimate the game-changing potential of the latter if they are exclusively focused on.

Lastly, the battlefield robotization process raises two types of essential questioning. The first concerns the nature of the intelligence architectures of the future, inasmuch as the emergence and generalization of robots add an unfamiliar loop to the classic intelligence systems. The second, in a wider political context, concerns a question that has already been alluded to via the process of outsourcing and the contractualization of withdrawal, and therefore the legitimacy of the State in coercion operations.

1. P. W. Singer, *Wired for War: The Robotics Revolution and Conflict in the Twenty-First Century* (New York: Penguin Press, 2009). For a French perspective on robotization, see for example: Jean- Jacques Cécile, *La guerre des robots. Les révolutions militaires de demain. (The war of the robots. The military revolutions of tomorrow.)* (Ellipses Marketing, 2006); Pierre Pascallon, *Demain, les drones de combat? (Tomorrow: combat drones?)* (Editions L'Harmattan, 2004). Marc Grozel and Géneviève Moulard, *Drones, mystérieux robots volants (Drones: mysterious flying robots)* (Lavauzelle, 2008).

2. Laurent Checola and Edouard Pflimlin, "War without pilots; Drones command the skies," *Le Monde Diplo-matique,* December 1, 2009; John Keller, "The Time Has Come for Military Ground Robots." *Military & Aerospace Electronics,* 20, no. 6 (2009): 24–30; Ellen M. Purdy, "The Increasing Role of Robots in National Security. Defense AT&L, 37, no. 3 (2008): 26–29; Alan S. Brown, "The Drone Warriors." *Mechanical Engineering,* 132, no. 1 (2010): 22–27: William Wong, "Unmanned Military Vehicles: Robots on the Rise." *Electronic Design* 56, no. 19 (2008): 30–34; Peter H. Lewis, "Iraq's Robot Invasion" *Fortune* 151, no. 1 (2005): 58.

3. Ferat Sahin, "Robotic Swarms as System of Systems" in Mohammad Jamshidi (ed.) *System of Systems Engineering,* (John Wiley & Sons, Inc. 2008), 482-519.

4. David Axe, *War Bots: How U.S. Military Robots Are Transforming War in Iraq, Afghanistan, and the Future* (Nimble Books, 2008); Leighton Hanon, "Robots on the Battlefield–Are We Ready For Them?" AIAA 3rd *Unmanned Unlimited Technical Conference, Workshop, and Exhibit* (2004): 20–23 September, Chicago; Peter Bergen and Katherine Tiedemann, "The Drone War" New Republic, 240 no. 9 (2009): 22–25.

5. Christian Malis highlights the recurrent time lag between the advent of progress in the sciences of weaponry and strategic thinking. See Christian Malis and Pierre Marie Gallois: *Géopolitique, histoire, stratégie* (Geopolitics, history, strategy) (L'Age d'Homme, 2009).

6. Consider for example the broad picture painted by Ajey Lele in *"Strategic Technologies for the Military: Breaking New Frontiers"* (Sage Publications India Pvt Ltd, 2009).

7. Elizabeth Bumiller and Christopher Drew, "Military Budget Reflects a Shift In U.S. Strategy," *The New York Times,* 6 April 2009. Christopher Drew, "Drones are Weapons of Choice in Fighting Al Qaeda," *The New York Times,* 17 March 2009.

8. Robert Ranquet, "Défense de la technologie" ("In defense of technology") Politique étrangère (Foreign policy) 4, (2009): 65-70.

9. V. Desportes, "Armées : 'technologisme' ou 'juste technologie'?" ("Armies: 'technologism' or 'just technology'?") *Politique étrangère* (Foreign Policy) 50, no. 2 (2009): 403- 418. Along the same lines: Thierry Allemand, "L'action militaire et l'impérialisme technologique" ("Military action and technological imperialism"), *Le débat stratégique* (The strategic debate) October, No. 176 (2009).

10. See the first difficulties in managing the information flows produced by drones in Christopher Drew, "Drone Flights Leave Military Awash in Data," The New York Times, 11 January 2010.

11. See the reactions of Afghan rebels to the use of drones in Yassin Musharbash, "In the Crosshairs–How al-Qaida & Co. Are Responding to Drone Warfare," Spiegel Online International, 12 March 2010.

12. See for example Didier Danet, "Quelle régulation pour les sociétés militaires privées?" ("What kind of regulation for private military companies?") in Christian Malis and Didier Danet (eds.) Frères d'armes? (Brothers in Arms?) (Economica, 2011), 77-90.

13. To illustrate these largely stereotyped discourses, see for example Marc Pitzke, "Remote Warriors–How Drone Pilots Wage War," *Spiegel Online International,* 12 March 2010. David Zucchino, "Drone pilots sitting in Nevada are just a click away from war in Afghanistan; Remote-controlled, unmanned planes are the vanguards of a revolution in warfare," *Vancouver Sun,* 25 February 2010. For a more subtle analysis, see Spiegel Online, "Interview with a Drone Pilot–'It Is Not a Video Game,'" *Spiegel Online International,* 12 March 2010.

14. Rajiv Chandrasekaran, "War, the old-fashioned way; Marines in Marja offensive find that the basics of battle haven't changed," *The Washington Post,* 20 February 2010. For a more nuanced overall reflection on this vision, see Christopher Coker, *The Future Of War: The Re-Enchantment of War in the Twenty-First Century* (Blackwell Publishing Ltd, 2004).

15. Lieutenant Colonel Lucciti, "Quels systèmes robotisés pour l'armée de Terre à l'horizon 2015?" ("What robotized systems for the Army looking ahead to 2015?"), *Objectif Doctrine,* No. 29 (2005): 46-54; Michel Asencio, *Digitazation and robotisation of the battlefield.* Notes of the FRS (Fondation pour la Recherche Stratégique) 2010.

16. Patrick Lin, George Bekey, and Keith Abney, *Autonomous Military Robotics* No. 1 US Department of Navy, Office of Naval Research, 2008.

17. Colonel Jean-Christophe Le Roux, "L'armée de Terre et la robotisation terrestre" ("The Army and robots on the ground"), presented at the symposium: "Robotisation du champ de bataille" ("Robotization of the battlefield"), Paris Ecole Militaire: Ecoles de Saint-Cyr Coëtquidan, CESAT, CDEF, 2010). http://www.st-cyr.terre.defense.gouv.fr/index.php?ID=1033179, (accessed 12 November 2013).

18. David Hambling, "Quick and Nimble. Researchers seek Ways to Increase Robot Mobility," *Defense Technology International* 3, no. 7 (2009).

19. According to the New York Times, the United States is said to have lost a third of the Predator UAVs engaged in Iraq and Afghanistan. Christopher Drew, "Drones are Weapons of Choice in Fighting Al Qaeda," *The New York Times,* 17 March 2009.

20. Bernard Bombeau, "Drones: gérer l'urgence, engager l'avenir" ("Drones: managing emergencies, committing to the future"), *Air & Cosmos,* 5 February 2010.

21. See, for example, Johnson et al., *Stratégique 8ème édition (Strategic 8th edition),* 8th ed. (Pearson Education, 2008). Chapter 14: Managing strategic change.

22. Adam N. Stulberg, "Managing the Unmanned Revolution in the US Air Force," *Orbis* 51, no. 2 (2007): 251-265.

23. Jacques Liouville, "Management de l'innovation et performances : bilan et leçons des recherches consacrées à l'ambidextérité" ("Management of innovation and performance: conclusions and lessons learned from research into ambidexterity"), *Rev. Fr. Gestion Industrielle* 28, No. 4 (2009): 83–108.

24. Gary E. Marchant, Braden Allenby, Ronald Arkin, et al. "International Governance of Autonomous Military Robots." *Columbia University Review of Science & Technology Law,* 13, 2011; Ronan Doaré and Henri Dude, *Les robots au coeur du champ de bataille (Robots in the heart of the battlefield)* (Economica, 2011); Armin Krishnan, "Automating War: The Need for Regulation" *Contemporary Security Policy,* 30(1), 2009, 172–193.

25. On this topic, see Ronald C. Arkin, *Governing Lethal Behavior in Autonomous Robots* (Boca Raton, Fla: Chapman & Hall/CRC Press, 2009). For a more critical perspective, see Noel Sharkey, "Robotics Today: The Good, Bad, and Ugly," 15th Annual IEEE International Conference and Workshop on the Engineering of Computer Based Systems (ECBS, 2008), 3-4; Robert Sparrow, "Predators or Plowshares? Arms Control of Robotic Weapons," *IEEE Technology & Society Magazine* 28, no. 1 (2009): 25- 29; Nathan, S. (2011). "Robot wars" Engineer. (00137758), 296(7818) (2011): 20–22.

26. See Christian Malis, “La robotisation de l’espace de bataille nous promet-elle une nouvelle révolution dans les affaires militaires ?” (“Does the robotization of the battlefield presage a new revolution in military affairs?”), *DSI* Special issue, No. 10, (2010).

27. See in this regard: Simon Lacroix, “L’état de l’art de la robotique militaire” (“The state-of-the-art in military robotics”) presented at Colloque “Robotisation du champ de bataille” (“Robotization of the battlefield”), Paris Ecole militaire: Ecoles de Saint-Cyr Coëtquidan, CESAT, CDEF, 2010.

28. Michael A. Goodrich and Alan C. Schultz, “Human-robot interaction: A survey,” *Foundations and Trends in Human-Computer Interaction* 1, no. 3 (2007): 203-275.

29. Suzy Killmister, “Remote Weaponry: The Ethical Implications,” *Journal of Applied Philosophy* 25, no. 2 (2008): 121-133; Philippe Frin and Ronan Doaré, “La robotisaton du champ de bataille : défis et enjeux juridiques?” (“The robotization of the battlefield: challenges and legal issues”), DSI Special issue, no. 10, March (2010).

30. Concerning this question, refer to the debate concerning the legitimacy and legality of attacks by UAVs against suspected enemies in the border zone between Pakistan and Afghanistan. Graham R. Shaw, & Majed Akhter, “The Unbearable Humanness of Drone Warfare in FATA, Pakistan.” *Antipode,* 44, no. 4 (2011): 1490-1509.

31. Aaron Schwabach, “Kosovo: Virtual War and International Law,” *Law and Literature* 15, no. 1 (2003): 1–21.

32. Jean-Paul Hanon, “Guerre, système international et robotisation” (“War, international system and robotiza-tion”), DSI Special issue, No. 10, (2010).

33. We may consider that the creation by the United States following the 9/11 attacks of a double “smart border” (electronic as well as physical) prefigures this automation of surveillance, the real efficiency of which may be called into question since it has never really succeeded in slowing down the flow of Mexican immigration into the southern USA.

34. See the example of the TerraMax robotized vehicle: Yi-Liang et al., “TerraMax TM: Team Oshkosh Urban Robot,” *Journal of Robotic Systems* 25, no. 10 (2008): 841–860.

35. See for example the recommendations designed to encourage the integration of human factors in complex systems: Anne Bruseberg and Georgina Fletcher, *The Human View Handbook for MODAF* (Systems Engineering & Assessement Ltd, 2008).

36. Robert Sparrow, (2007). Killer Robots. *Journal of Applied Philosophy,* 24, no. 1 (2007): 62–77.

37. J. Storrs Hall, *Beyond AI: Creating the Conscience of the Machine.* (Prometheus Books, 2007).

38. It is not irrelevant to point out in this respect that the mastery of IT technology is fairly widespread in the emerging countries, and that many non-State players are capable of designing and deploying robots which are fairly basic but perfectly suited to essential functions such as observation or the destruction of objectives.

Part One

The Military Robot: A New Stage in the History of Arms

Chapter 2
Robotic and Future Wars:
When Land Forces FaceTechnological Developments
by Antonin Tisseron

Introduction[1]

Despite the fact that over the past 10 years, robotics fans among the general public have endured one disappointment after the next, having to content themselves with little more than a vacuum cleaner, while Sony closed down its robotics division, robots have invaded the battlefield.[2] Since 2002 and the death in Yemen of the terrorist Abu Ali al-Harithi, killed by a missile from a CIA *Predator* UAV, the offensive use of UAVs has become increasingly frequent for targeted assassinations. The US relied on UAVs to such an extent, that for the former director of the CIA, Leon Panetta (2009-2011), armed UAVs seemed to be the only efficient weapon to combat Al Qaeda worldwide.[3]

The growing use of robots is not limited to the "war on terrorism" and special operations. Between 2003 and 2007, 10,000 improvised explosive devices (IEDs) are said to have been destroyed by 5000 robots of the US Army, some of which have been given nicknames and dummy ranks by their operators. Likewise, these small devices, popularized in the film *The Hurt Locker,* only constitute a fraction of the robots deployed by the armies on the ground. Without harking all the way back to the German remote-controlled *Goliath* beetle tank of the Second World War, armies have possessed remote-controlled tanks since the 1970s and, in recent years, several devices have been developed which are capable of transporting a ton of payload and are able to be weaponized. Armies also use, in conjunction with the Air Force, their own UAVs, for supporting maneuvers, acquiring intelligence, providing covering fire, protecting the forces by means of their dissuasive effect, and enhancing the quality of wireless communications by serving as relay stations. In the operations that it carries out in Afghanistan, the French Army therefore distinguishes between UAVs functioning at operational level, those involved in the tactical operations zone, and mini-UAVs (local level).

Do robots mark the advent of a new age of warfare? The impact of air/ground robots on the grammar of the battlefield is not clear, and there are two opposing—though not necessarily mutually exclusive—approaches to this. The first approach, a visionary one, considers robots to be the embodiment of a game-changer, comparable to the introduction of gunpowder in military forces. The second, more pragmatic, emphasizes the immutability of the rules of war and the uncertainties linked with these new tools.

Within land forces, for mainly organizational and budgetary reasons, the second approach tends to dominate, with many questions being asked about the integration of robots. Yet behind these uncertainties, robotics is only in its fledgling stages and robots will most probably become increasingly commonplace in the wars of tomorrow, which means that questions have to be asked about the way in which they affect and will affect battlefields, along with how we are to understand them. This, in any case, is the objective of this essay, designed above all to provide grist for the mill of future debates.

The Robotization of Battlefields

When the US Army V Corps entered Iraq in 2003, it had only one UAV and no ground robots. Five years later, 12,000 unmanned ground vehicles (UGVs) were engaged in the theater of operations, principally for the purpose of reconnaissance, the destruction of explosive devices, or the interception of shells and rockets.

When Armies Turn to Robots

The Iraqi and Afghan theaters of operation have constituted vast centers of open-air experimentation for the robots of tomorrow. *The Big Dog*, a quadruped robot capable of accompanying infantrymen in rugged and mountainous terrains, for carrying kit and other heavy loads (up to 150 kg) at a speed of 4 km/h, is one such robot that has been sent to and tested in Afghanistan.[4] Another example is the SWORDS (Special Weapons Observation Reconnaissance Detection Systems) mobile robot armed with machine guns which was deployed in 2007 in Iraq, and which was also deployed in Afghanistan, where it is said that the Taliban succeeded in flipping over the devices and recovering their weapons and ammunition. Its successor, the MAARS (Modular Advanced Armed Robotic System), is indeed a heavier unit. It can be fitted with a range of different weapons: machine gun, grenade launcher, rocket launcher, along with loudspeakers to encourage the enemy to surrender or ask the population to leave the area. It can also be programmed to define "firing zones" and "exclusion zones."

The United States is not alone in testing tomorrow's tools of war in current operations. Israel is also at the cutting edge in the field of battlefield robotization, with work directly drawing on recent combats. Upon returning from the 34 days of violent confrontations in Lebanon during the summer of 2006, the engaged Israeli units reported their difficulties in flushing out Hezbollah fighters entrenched in a network of fortified subterranean shelters built under the direction of Iranian and North Korean engineers. Researchers from Ben-Gurion University, in collaboration with those of Technion-Haifa, subsequently came up with and developed a 2m-long snake-robot, capable of crawling along narrow tunnels. This robot's head is made up of sensors and cameras that send information back to the soldiers remaining in the rear. It can also be used for placing an explosive charge. As far as the border with Lebanon and the Gaza Strip is concerned, in order to limit attacks on patrolling troops, surveillance is provided by a remote-controlled device called the *Guardium*. The robots are a technological resource taking their place alongside the fences or walls of closed borders.

Robot development is a wealth creation factor. The State of Israel has well understood this, not contenting itself simply to exhibit its technological arsenal as a means of dissuading States and groups considered as hostile. Many Western armies engaged in Afghanistan use Israeli-origin unmanned aircraft for reconnaissance or destruction missions and, in 2008, Israel replaced Russia as the number one supplier of weaponry to the Indian Army. In South America, Brazil, and Colombia have purchased Israeli UAVs, and security at the 2010 FIFA World Cup was largely provided by Israeli companies. Although there may be many economic outlets for companies designing and manufacturing robots for security usages, the technologies developed can also be used on robots designed for civil protection, industry, individual leisure, domestic tasks, or simply for keeping people company. These are all fields in which the needs are exponential on account of the aging of the populations in the wealthier nations, the growing recourse to technology for work in factories or the management of risks and disasters as well as, more generally, the importance of technology in our environment and for managing problems.

The Sources of the Robot's Appeal

The prime military interest in robots comes from the fact that they help to save lives. This, in any case, is the credo of the manufacturers and one of the driving factors in the use of robots in the Armed Forces. Interviews conducted in the United States by Second Lieutenant Piraud, for his final year dissertation at the Écoles de Saint-Cyr Military Academy, demonstrate that the reduction in combat losses is indeed considered to be one of the main advantages of the use of robots.[5] Thanks to robots, human beings can be less exposed to risks, and it is better to lose a robot than a soldier to the blast from an explosive device, an ambush, or a skirmish. US Army Lieutenant General Rick Lynch said very much the same thing when he stated at a conference in 2009 that out of the 155 men in his unit killed in Iraq, the lives of 122 of them could have been saved by using robots.

If the importance accorded to the preservation of life in Western societies and the perception of death in combat in limited-scale warfare in complex environments—Iraqi towns, Afghan caves, and Lebanese tunnels—have driven the acquisition of robots in the US and Israeli armies, the utility of robots takes can be seen in three other dimensions.

Robots are first of all perceived as tools that increase the operational efficiency of military forces. Although the reduction in military personnel numbers is a growing phenomenon, the fewer personnel must not only be capable of controlling zones covering larger areas than in the past (without necessarily occupying them), but also of doing this more rapidly. As the doctrinal philosophy of the Americans and Israelis would have it, "you need to see, understand and act more quickly than the enemy, in order to keep them in a permanent state of shock."[6] A robot is both a response to the growing scarcity of human resources in the military, against the backdrop of the prospect of urban operations placing heavy demands on the infantry, and a tool enabling operations to be accelerated.

Secondly, a robot is not subject to lapses in concentration and is not subject to the same physiological limitations as the human body. It does not get hungry, does not get frightened, nor does it forget orders, provided that they have been correctly fed in or that the link with the operator has not been broken. It can carry out mine clearance all day long, operate in radioactive environments and fire with greater precision than a soldier. One of the arguments for vaunting the merits of the SWORDS system is, indeed, that the robot can hit a coin at a distance of 300 meters, whereas the precision of a trained infantryman at such a distance is limited to a target the size of a basketball. Better still, even if the manufacturer prefers not to say so, unlike the soldier the robot will not hesitate to shoot to kill. The idea underlying this discourse is that of outstripping the limits of man in the name of military efficiency, of realizing the age-old dream of institutions built upon reducing the frictions that are linked to the human factor thanks to the use of soldiers that act like machines.[7]

Lastly, from an economic point of view, the cost of a robot is less than that of a soldier in operation. An American soldier sent to Afghanistan equates to a cost of $1 million per year, training included. In comparison, a Packbot costs around $150,000 and a *MARCbot* $5000.[8] This, moreover, is without taking into account retirement costs. The Pentagon owed its soldiers, in 2010, $653 billion for their future retirement pay, resources the Pentagon simply does not have. To these direct costs may be added the costs of evacuating and tending for the wounded, and their post-conflict reintegration. The duty of coming to the aid of a brother in arms also does not apply to a robot, which can be destroyed by a bomb or other explosive to prevent it falling into enemy hands, at least in theory. In Iraq and Afghanistan, US combatants in fact risked their lives to recover robots described by their commanders as tools of great value that needed to be taken care of, running counter to the economic argument and the desire to limit human losses. Another driving factor in endangering men's lives in order to "save" a robot is the emotional link projected by the combatant on the machine that he or she fights alongside, and which may lead him to seek to rescue the robot in a danger zone at the risk of his own life.

American Ambivalence

According to certain forecasts, in several years a third of everything that is flown, navigated or driven in the Israeli army will be under remote control.[9] In the United States, a comparable proportion of manned and unmanned vehicles were posited in the National Defense Authorization Act of 2000. By way of two mandates from the US Congress, the objective was set for 2010 that one third of aerial strikes deep within hostile territory will be carried out by unmanned aircraft and, for 2015, that one third of ground combat vehicles would be unmanned. This objective was also recapitulated in *Robotics Strategy White Paper,* written for the US Army in 2009, the purpose of which was to guide reflections on robotics in that force.[10]

In recent years, the "robotics strategy" of the US Army has been driven by the development and use of systems available in the framework of the Rapid Fielding Initiative, and the Joint IED Defeat Organization, designed to address the immediate needs of soldiers engaged in theaters of war.[11] Concerning the preparation in the near future of land forces, robotization was included in the framework of the Future Combat System (FCS) program, under the aegis of DARPA and cancelled on 23 June 2009 in favour of the Brigade Combat Teams Modernization (BCTM) program.[12]

As it happens, then, far from an "all-technological" vision, it is rather a certain ambivalence with regard to what robotics has to offer on the battlefield which predominates within the BCTM program. The elimination of the FCS program was indeed accompanied by the abandonment of several initially planned robotic capabilities. Beginning in June 2009, three systems were therefore cancelled since they were judged not to offer added value with respect to the envisaged needs and the most probable threats.[13] This involved the class IV UAV (brigade level) and the logistics and mine clearance versions of the MULE (Multi-Function Utility/Logistics and Equipment) vehicle. All that were retained in the framework of the incremental 1 program for implementation in 2011-2012 were distributed autonomous sensors including one model for urban zones, a class I rotary wing mini-UAV project (section level, employed in particular by the US special forces and in certain specialties), a first type of unmanned ground vehicle, a kit enabling integration of all these elements with the C3 (command, control and coordination) network, a new model of inter-service radio and an indirect precision firing system called NLOS (Non Line Of Sight Launch System)designed to fire 15 missiles that are capable of tracking their target and are reprogrammable in-flight.[14]

The NLOS was abandoned in May 2010. On 12 January 2011, the BCTM program was pared down further with the ratification by the Pentagon of the request of the US Army to no longer include in it the class I UAV and the sensors. This decision was followed, on 29 July, by the cancellation of the latest still-maintained version of the armed and combat-ready version of the MULE. All that remains of the defunct FCS program are the systems of communication and the small, unarmed ground robots, used for the reconnaissance of buildings, caves and tunnels. Against a backdrop of scepticism with regard to the technology along with ever more stringent budgetary constraints, the US Army has chosen to concentrate solely on the clearly identified needs of soldiers, while continuing to pursue research and development.

The Start of a New Story

Despite the setbacks to US-style robotization for the proponents of an "all-technological" approach, the robots appropriation phase is gradually giving way to a phase of development and expansion of the field of action of robotized systems. New usages are being envisaged, indeed discussed, but not without feeding into fears about the future of warfare.

Development and Diversification

With robots being so visible, used on the ground and deployed in various operations, every military professional is at liberty to conceive uses to satisfy his or her needs. "*In the case of robots,*" Colonel Michel Goya writes, "we need to bear in mind this lock-in effect created by the first mine clearing devices, in order to go beyond it and imagine other ramifications in line with a cumulative and exponential process."[15]

According to this perspective of progressive introduction—inseparable from the growing use of robots in civil domains and from the technological progress being made—the US Department of Defense identified four priorities for robotized systems looking forward to 2030: reconnaissance and surveillance, the identification and designation of targets, neutralizing explosive devices, and reconnaissance in contaminated, polluted or booby-trapped zones.[16] However, these orientations do not exclude the possibility of pursuing work in other directions, as is suggested by the authors of the *Robotics Strategy White Paper,* who distinguish five possible fields for the deployment of robots: logistics, security (understood as the protection of sites and locations or the control of traffic flow), clearing up the battlefield, health and maintenance. Rather than coming up with programs along set budgetary lines, it is above all a matter of determining broad orientations designed to create synergy in terms of research and costs between the different branches of the armed forces, and encouraging the sharing of information.

We are still a long way away from replacing the human combatant with the machine. The second element to be considered with regard to current processes is that the integration of ground robots will not follow a linear progression, and a lot of persuasion will be necessary. In the United States, even if the operations in Iraq and Afghanistan have spurred on the search for robotized solutions to counter IEDs, the main financial contributor in this area has been the US Navy. Likewise, the abandonment of several projects in the BCTM program testifies to the extent of the questions being asked within the US Army, heightened by budgetary restrictions. However, it should not be forgotten that robotics is not solely the fruit of military research alone. The US Federal budget in 2012, for example, earmarked $30 million for the National Robotics Initiative, an inter-agency program incorporating among others NASA and the Department of Agriculture, and designed to accelerate the development and use of robots alongside human beings. Within this context, asking questions in the armed forces about the integration of robots amounts in effect to preparing for the wars of tomorrow.

On the Utility of Robots in Ground Combat

While military reflections on what robotics has to offer in the fields of logistics and medical evacuation reflect the desire to economize on human resources and save the lives of soldiers, the tactical utility of robots relates to the capacity of military forces to get the upper hand over the enemy on the battlefield, this being the primary and priority mission for all military tools.

Would the Uzbeen ambush on 18 August 2008, in the course of which 10 French soldiers were killed, have gone any differently if the section of the 8th RPIMa (Marine Infantry Parachute Regiment) had possessed robotized systems? Initially, a UGV or a UAV could have been used for reconnoitering and approaching the mountain pass, in order to observe the opposite flank. Once the section had been engaged by the Taliban, robots could have reinforced the defensive measures of the Paras, supplied ammunition or deployed weapons in order to get the better of the enemy combatants.[17] These armed robots could also have been kept with the rearguard in order to provide long-range cover, both precise and insensitive to enemy suppressive fire.

Questioning what ground robots could have contributed to Uzbeen amounts to examining their utility on the battlefield. In this regard, it is already possible to observe that reconnaissance has proven to be one of the two essential missions of robots today, alongside the neutralization of explosive devices. Yet to return to the case of Uzbeen, the added value that a ground robot might offer for observation compared to a drone is not evident. On account of its position, the drone would offer a better view of the mountain pass and its surrounding area. As long as it is controlled by an operator outside of the unit, it is not part of the “payload” of the unit. Lastly, it may be armed. All of this notwithstanding, a ground robot has two advantages over its aerial counterpart with regard to reconnaissance missions. On the one hand, it can use the resources in the field to progress under cover to places that a soldier cannot reach, and provide information about the suspect element following processing. In this way it would act as a discreet sensor and mobile manipulator, and is moreover used in this function by police units and special forces in several countries. Also, UAVs have difficulty observing closed environments, such as the interior of a room or a cave (except for the smaller drones).

Concerning uses other than reconnaissance, there are multiple possibilities: protecting sites and bases, destruction-neutralization of enemy elements or equipment, diversions when triggering an offensive, or covering the flanks of armies operating in vacuum areas, etc. It is for example possible to envisage, when capturing a village, deploying robots to control the open spaces or a road link, with the robot offering the benefits of its precise sensors and its weaponry without exposing a forward group. Israeli laboratories and manufacturers, whose country is in conflict with identified and known enemies, go further still. Robots need to make it possible for enemy leaders to be hit wherever they may be. So it was that during Operation *Cast Lead,* at the turn of 2008-2009 in the Gaza Strip, the Hamas leaders were said to be hidden beneath the pediatric wing of Shifa hospital, making it impossible to eliminate them through bombing or the dispatching of commandos. Yet a very small "killer" robot would have been quite capable of accomplishing the task. Against another army, and along the same lines, another Israeli project being studied consists in sending swarms of kamikaze drones against enemy batteries, according to an approach based on saturation, comparable to the doctrinal reflections carried out in Iran and China in the field of naval warfare.

Autonomy: an Essential Question

Any reflections on the use of robots invariably relate back to their autonomy. The soldiers who came under ambush in Uzbeen had other concerns than preparing a robot designed to be sent into the enemy positions and piloted by one of the members of the section. They had neither the time nor the human resources to control one or more robots.

To bring real tactical added value to armies affected by reduced numbers, the autonomy of robots is essential in this regard. It is first of all a means of getting away from the notion of one operator (or several operators) for one robot, and having several devices controlled by one operator. This implies an autonomy of movement and a capability to identify potential targets, a sound or vision system to warn of intruders, even automatic firing capability in certain armies. In the field of anti-aircraft combat, the US Navy thus considers the involvement of man in the decision-making loop to authorize opening fire with the Phalanx system as a factor that limits optimal defense capability. On the border between the two Koreas, the SGR-A1 system, deployed by South Korea, also has autonomous targeting and capability to initiate fire. As far as the US Army is concerned, it is said to have developed "robotized snipers," and the Norwegian manufacturer, Kongsberg, is said to propose a turreted system capable of firing autonomously. There are high-tech devices designed to take the place of the soldier in the modern arena of battle, with automation appearing desirable on account of the performance and efficiency it offers.

With this in mind, the capability of discriminating between targets is one of the main issues linked to robotics: distinguishing friend from enemy, combatant from civilian. Yet as pointed out by the authors of a report from the Office of Naval Research of the US Navy, even if discrimination is above all a matter of making progress in programming and artificial intelligence, other approaches are being explored: deploying armed robots exclusively in "kill boxes;" programming the robot to fire exclusively on vehicles or weapons; or equipping it only with reduced lethality weapons.[18]

There remain however many ethical and legal problems and, for the countries that signed the Ottawa Treaty its observance requires that human control is exercised over the weapons of a robotized system.[19] Behind this approach to man and warfare, the fact nonetheless remains that autonomy is what makes robots so useful. The combatant must be able to assign a mission to a robot and then concentrate on other tasks, while being able to receive any warning messages and taking control of the program, for example in order to identify a potential target and, if necessary, authorize opening fire (by the robot or not). The robot—or the group of robots—resembles in this regard a simple pawn in the hands of the section leader, comparable to a combatant or a fire team carrying out a mission and reporting back if required.

Fears, Questions, and Reproduction

Even if technology is the stuff of dreams, it can also breed fears, and not just because a robot can get "bugs." Indeed, as the popular saying goes, to err is human. Nor is it simply the fact that by entrusting your future to a robot you are entrusting it to something whose operation is only understood by a handful of engineers.

Mistrust about machines relates first and foremost to the representations of warfare and the profession of the soldier. For soldiers who place honour and passion at the heart of their profession, constructing robots to wage war without men amounts to creating inhumanity.[20]

This mistrust, however, extends beyond just the framework of the military institutions and the war machine. "Today, more than ever," says the robotics engineer, Frédéric Kaplan, "our Western conception of man is entirely founded in our appreciation of the performance as well as of the limits of machines. We see ourselves reflected in the mirror of the machines that we are able to build, and in this reflection we evaluate our difference."[21] In other words, with each new machine, there is a potential redefinition of our humanity, of that *"something"* which makes human beings different from these animated objects which are sometimes endowed with speech. The second implication, in order to prevent a machine calling into question this very foundation of human nature, is that it needs to be set against man. Hence the appeal of the argument: *"Machines only do what they're programmed to do, they don't 'understand' what they do; we have emotions, machines only simulate them."*[22]

As well as this identity dimension, the integration of robots within military forces begs the delicate question of "what to do with them." Aside from the applications of reconnaissance in confined spaces and the neutralization of explosive devices—missions, ultimately, which equate to excessive exposure to danger, the paradox of a profession in which danger is by definition accepted—the use of robots remains an extremely grey area. One of the interviews conducted in the United States by Second Lieutenant Piraud with a professor at the US Naval Academy, offers revealing insight into this:

> Second Lt Piraud: "How do you go about taking into account the needs of the army?"
>
> Professor B: "Well, I sit at my desk, as I'm doing here, with a naval officer, say. I explain to him what I'm technically capable of doing. I explain to him that, in order for me to design something, he needs to give me a mission to fulfill for my robots, a precise mission. The problem is that he himself does not know what he expects from me, he does not know what mission these robots may be used for."

Many people outside the military also note this lack of an overcharging plan. *iRobot* executives complain that the military forces "still think of robots as RC [remote-control] cars."[23]

The various armed forces do not all have the same relationship with technology. The Air Force tends to be more technophile than the Army. However, this absence of vision is a classic feature of the innovation process in institutions.[24] The users, used to working with their usual tools, do not necessarily perceive the potential applications of new equipment which do not fit the box of institutional thinking. Bureaucracies are loath to innovate, and tend to favor progressive changes based on legacy. Reluctant to change, they are themselves designed not to change, with a whole set of mechanisms whose purpose is to produce stability. Therefore, when the impact of new technologies in terms of costs and utility is not clear, and when these come into conflict with the *ethos* of a section of the profession, the tendency to pursue what you know how to do predominates. Even so, warfare is undergoing change.

On War in the Age of Robots

Will robots change the course of warfare? For Peter W. Singer, far more than the Internet and a network-centric approach that has proven incapable of dispelling the fog of war, robots constitute a "revolution" affecting how to fight and who does the fighting.[25]

Robotic Game Changers....

The technological breakthrough that robots represent is exercised first of all in the relationship between people and war. During the 20th Century, war was waged by people subject to conscription. With professionalization, this link was weakened, and with robots, the dissociation between society and the use of armed force has increased in amplitude. Consequent to the reduced risk of friendly human losses, war appears to be a far easier tool to use with far less risk for the decision-makers.

If this notion takes in the work involved in coercive diplomacy along with the experience of the war in Kosovo and the operations conducted by the UAVs of the CIA in Yemen and Pakistan, the passivity of public opinion is not limited to wartime, and is part of a more general groundswell. Sociologists indeed concur in observing a lesser role for the people within democracies, and not only in Europe or North America. More precisely, as Pascal Vennesson points out, "The forces of democracy remain unchanged, but a system of governance has been put in place in which the people play a diminished role, while the reality of power is increasingly controlled by the elites."[26] Even after the 9/11 attacks in 2001, American society was barely affected by the active participation of the people: no mobilization, few mechanisms to give local communities a voice with respect to national projects, the choice of the authorities to take recourse to an intervention in Afghanistan led by special forces against a background of professional management of media messages by the political authorities and not-for-profit associations.[27]

A second development is that the sensors of drones and robots enable what Peter W. Singer calls the rise of the "tactical general," echoing the notion of the "strategic corporal" developed in the 1990s.[28] The profusion and availability of images, added to the small number of active personnel in the theaters of operations, indeed encourage the telescoping of the levels of decision-making, with the interference of the highest echelons in the scope of responsibility of the lower echelons, which are thereby divested of the exclusive assessment of the tactical situation. Yet, here again, this trend goes back to before the introduction of robots in the Armed Forces. Robots are only mobile sensors, whose cost of acquisition and operation facilitates their multiplication.

For the combatant, or at least for some of them, the break is still cleaner. With the distancing from the battlefield, the controllers of drones in the United States experience the war at long-distance, in front of a screen, back in their own country. It may be considered in a way as the ultimate stage of development initiated with the invention of the slingshot, then continued with the bow and arrow and then the firearm, and consisting in getting as far away as possible from your enemy in order to kill them, and so reducing the risks of getting killed yourself. For the military, it is therefore the experience of combat that is changing. There is no longer any need to depart for an operation. It is possible to work inside a room, sheltered from any threat, commanding machines to fire missiles between two coffee breaks, and then going home in the evening for dinner with the wife and kids.

…. and the Invariables of Warfare

These breakthroughs, according to Peter W. Singer, are simply the premises for a revolution. The robots of tomorrow will be far more sophisticated than those of today and, following on from robots which depend on men, there will be more and more men who depend on robots.

At the same time, however, the introduction of robots does not change the essence of warfare. Certainly, the drone missions operated by the CIA testify to the greater liberty of action open to the US security services thanks to robotics. Yet clandestine operations existed well before the development of these devices. War remains a confrontation of wills between two entities or groups which use their resources—human and economic—in order to produce a state that they consider to be better. "At the end of the day, whatever technological 'revolutions' there may be, war does not change its very nature. […] Robots, however sophisticated they may be, will not be able to replace the essential: our determination to assume the cost of combat."[29] However, what may well be changed is the accepted and assumed cost: less blood spilled, yet just as much or indeed more money expended. Far more than the issue of the population, it will be the economic and technological capacities that will be crucial in the wars of the 21st Century, along with the capacity to integrate robots, their quantity, and how they fit in with the other units.

According to this perspective of war as a social phenomenon, several pundits, such as the Australian David Kilcullen, and the American Ralph Peters, have denounced the counter-productive use of robots on the strategic level. According to this argument, robots undermine Western societies and their credibility, and the use by foreign armies of robots also testifies, in the minds of the Afghans, to the incapacity of the Americans and their allies to protect them.[30] This argument, which relates to the meaning of war and how it is understood by the other parties present, needs however to be placed in a broader context. The image of foreign armies is not conveyed simply through their recourse to robotics. In fact, this chimes with the feeling that Western armies would be unwilling to lose too many of their soldiers in Afghanistan. This criticism is not new, and it is fanned by the propaganda of the Taliban and their allies. Also, even for Lyautey, the icon of a certain idea of counter-insurgency, the use of force to suppress any notions of revolt would appear to be a necessity. In this sense, robots may conversely create a situation of superiority, propitious to the implementation of stabilization operations.

There can be no technical solution, moreover, without an operational doctrine. The example of French tanks during the campaign of May-June 1940 is quite familiar: despite possessing fewer tanks, and of inferior quality, than the French army, the German army was able to make better use of them by grouping them into armored divisions.[31] Even if today robots are employed in support of units, Singer insists quite rightly on the need to ask questions about the development of a doctrine. Should we employ robotized platforms like humanized platforms? Should we, conversely, develop new doctrines in order to take account of the innovation constituted by the advent of robotized systems?[32]

Still, according to Singer, the doctrinal debate is structured around two approaches strongly influenced by reflections in the aviation and naval fields: the "mother robot" and "robot swarms." The principle of the "mother robot"—sometimes called "marsupial robot"—corresponds to the concept of having a main robot (or else a manned vehicle) which carries with it other, smaller robots. The main robot may be either autonomous or remotely controlled, but the robots depending on it are themselves quasi-autonomous. The second concept of use, "robot swarms," is also inspired by the animal world. Swarm systems seek to reproduce the behavior of predators which hunt in packs or of birds and bees which work together. Each animal chooses how to move individually but altogether they form an organized and efficient group. These two approaches offer rich potential, with the choice between the two being based on the robots developed, their missions and the considered timeframe. For surveillance or attack robots, the swarm makes it possible to create functional redundancy, to saturate the enemy defenses, and to limit the cost of the robots destroyed. Conversely, in the case of robotized support weapons or larger robots, centralization may seem more appropriate, with a human team controlling several robots.

Whatever the case, the doctrinal aspect of the integration of robots, a new tool in the hands of the military organizations, is all the more important insofar as they are not the sole province of the Western armies. During the war in the Lebanon in 2006, the Hezbollah combatants used several types of robots against Israeli forces and, today, over 40 countries are working on robotization.

Robots and the Action-Reaction Cycle

Unlike in the Second World War, in the field of robotics it will no longer be the size of the gun or the skill of the gunners, the fact of possessing radios or else the size of the fuel tanks which will make the difference between two armies, but the program of the robot and its capacity to tackle the threats and pitfalls of the battlefield. For every action there follows a reaction, according to a cycle whose only notable variable is the duration.[33] In Afghanistan, to prevent mine clearance robots from accessing explosive devices, the latter were installed in garbage cans, or in camouflaged holes. Another example, in 2009, involved Iraqi insurgents who, probably with the aid of Iran, intercepted images transmitted to American units on the ground by a *Predator* drone, using software enabling the pirating of TV broadcasts via satellite, such as the *Sky Grabber* program, which could at the time be downloaded from the Internet for $26.

The advent of robots has therefore created fault lines, of which piracy is but one expression. More generally, the choice of using remotely operated robots brings into focus the fragility of the link between the robot and its operator: limited available bandwidth, vulnerability of the data flows, absence of security for the civilian satellite resources used by the European armies, against the background of a growing threat of cybernetic warfare (or of a cybernetic dimension in a conflict). Even autonomous robots are reliant on these links, whether for communicating with one another or for receiving modified commands. By way of example, the guidance of French *Harfang* drones in Afghanistan is carried out through the rental of a civilian satellite shared with certain international mass media.

Another possibility resides in fooling the sensors, as the Taliban are already doing in Afghanistan, or in artificial intelligence. Once the behavior of the robots has been analyzed, the enemy combatants will put in place traps designed to fool, or even destroy them. Each conflict serves as a reminder that combatants learn according to a learning curve, and following the introduction of new equipment, the observation phase is succeeded by the implementation of countermeasures. At all levels of warfare, superiority generates a logic of working around and exploiting vulnerabilities, starting with the power requirements of the robot and the link connecting it with its army.

Conclusion

The robotization of the battlefield has barely been sketched out. Until now, the use of robots on the battlefield has been informed by lessons learned from the experience of the conflicts in Iraq and Afghanistan and, for Israel, in the Near East. For military organizations, understanding the impact of the technological innovations on future wars is not, however, self-evident. As pointed out by the historian, Martin van Creveld, in his book *Technology and War: From 2000 B.C. to the Present,* "during the 20th Century, […] none of the main equipment that transformed warfare—from the aircraft to the battle tank…—was born out of the doctrinal needs formulated by people in uniform."[34]

The main difficulty of armies when faced with this technological innovation resides in the uncertainties concerning the enemy, along with the costs and utility of the technical responses. The scientists, for their part, have no more clearer vision than the military of the advantages of the technological innovations for the military. In such a context, the US academic, Stephen P. Rosen, considers that military forces need to adopt a technological approach favouring versatility, adaptability and flexibility, in other words, to work towards producing equipment that could be used in the majority of situations, corresponding to current economic and human constraints and to what we learn about the enemies of today and of tomorrow. Likewise, for models or technologies that carry with them too great an uncertainty, a complementary approach consists in pursuing research and development and asking questions regarding usage, while postponing decisions for large-scale production and favoring an exploratory approach within a military force in order to define uses and doctrines.[35]

Even if strategies do exist for controlling uncertainty—as applied by the US Air Force and Navy with regard to missiles between 1945 and 1955—their success nonetheless implies manufacturers continuing to pursue their work, decision-makers allocating resources, but also reflection within the Army on the impact of robotization on the battlefield and the possible uses for robots. In this regard, the publication by the French Army chief of staff of an exploratory concept constitutes incontestable and, above all, necessary progress for any future developments in the field of robotization. The fact remains that the regiments and military schools are also major players with regard to the experiments and brainstorming conducted in association with the chiefs of staff and the intelligence services in order to identify needs, move beyond the traditional reluctance to change, and favor the circulation of knowledge and ideas.

Robotization, in correlation with nanotechnologies, expands in any case the range of possibilities for producing new equipment that could meet precise needs in conjunction with the existing tools. Yet we need to keep in mind that many of the future uses of robots still remain imponderable. "Before a new weapon reaches full maturity," wrote Camille Rougeron in 1939, "its use goes through several stages: the first is as a modest auxiliary for the weapons currently in place....In the second stage of its development, the new weapon is admitted into direct combat use....In the third and last stage, it has its own specific missions created for it, which now are only indirectly related with how the conduct of operations was envisaged prior to its conception."[36] As such, tomorrow's wars have only just begun.

Notes

1. This text is a slightly abridged version of a document produced for IRSEM in 2011.

2. For the US essayist, Peter W. Singer, a robot is defined by four criteria: it is a machine constructed by man; it possesses sensors in order to apprehend its environment; it is programmed in order to be able to define a response; and it is able to implement this response (P. W. Singer, *Wired for War,* New York, 2009). This definition enables the inclusion of fixed systems, whereas other definitions exclude them, considering mobility to be a criterion that defines a robot.

3. Éric Germain, "2010: année zéro des guerres robotisées" ("2010: year zero for robotised wars") *Revue Défense Nationale,* No. 740, May 2011, 119-121. According to Éric Germain, armed US drone strikes are said to have killed 1000 people in 2010 in the Afghan-Pakistani theater of operations.

4. The benefits expected by the promoters of UGVs include reducing the loads carried by combatants and thereby improving their capability to take cover and increasing their firepower.

5. Final year dissertation of Second Lieutenant Piraud, defended at the Écoles de Saint-Cyr Coëtquidan, 2010.

6. Joseph Henrotin, "La robotique, acteur de la contre-insurrection?" ("Robotics: protagonist in counter-insurgency?"), *Défense et Sécurité Internationale* (International Defence and Security), No. 10, Special issue, 2010, 72-74.

7. On the training of bodies, see the works of Michel Foucault. See also the work of S.L.A. Marshall on the Second World War (S.L.A. Marshall, *Men Against Fire. The Problem of Battle Command,* (Norman, 2000).

8. P. W. Singer, *Wired for War,* 22, 32.

9. Jean-Marie Hossate, "Quand Tsahal roule des mécaniques...high-tech. La guerre télécommandée" ("When Tsahal flexes its high-tech muscles. Remote-controlled warfare"), *Le Monde Magazine,* 4 September 2010, 26-29.

10. *Robotics Strategy White Paper,* March 2009. This document was the result of collaboration between the US Army Training and Doctrine Command (TRADOC) and the Tank Automotive Research, Development and Engineering Center (TARDEC).

11. The Rapid Fielding Initiative was first conceived in 2002, in response to the equipment needs of the soldiers deployed in Afghanistan. This came about because the military institution had come to realise that these soldiers, or their units, were buying their own equipment in order to mitigate the lack or inadequacy of the equipment provided in the theater of operations. In France, "operational emergency" purchases follow the same principle; the Joint IED Defeat Organization was urgently launched by the Pentagon to counter the threat represented by improvised explosive devices. Between 2004 and 2006, over $6 billion were spent on this program. These efforts culminated in particular in the development of MRAP (Mine Resistant Ambush Protected) vehicles, designed to be particularly resistant to mines and other improvised explosive devices.

12. When launching the FCS program, General Shinseki turned towards DARPA on account of the agency's experience in the management of conceptual and difficult projects, but also because he could anticipate opposition on the part of the upper echelons of the American army, which would have preferred more tanks and armored vehicles (Andrew Feickert and Nathan Jacob Lucas, *Army Future Combat System (FCS) "Spin-Outs" and Ground Combat Vehicle (GCV): Background and Issues for Congress,* Congressional Research Service, 30 November 2009, 2.

13. General George W. Casey, Jr., "BCT Modernization: Versatile Capabilities for an Uncertain Future", globalsecurity.org, 19 February 2010.

14. Classes II and III correspond, according to the classification of the FCS program, to the company and to the battalion respectively.

15. Michel Goya, “Quand la machine s’éveillera” (“When the machine will wake up”), *Défense et Sécurité Internationale* (International Defence and Security), No. 10, Special issue, 2010, 31.

16. *Office of the Secretary of Defense Unmanned Systems Roadmap* (2007-2032), December 2007. This is the first edition of the document.

17. Michel Goya, “Des robots à Uzbeen” (“Robots in Uzbeen”), *La lettre d’analyse du Centre de Recherche des Écoles de Saint-Cyr Coëtquidan (Letter of analysis of the Écoles de Saint-Cyr Coëtquidan Research Centre),* No. 1, 10-11.

18. Patrick Lin, George Bekey, and Keith Abney, *Autonomous Military Robotics: Risk Ethics, and Design,* report produced by the California Polytechnic State University for the Office of Naval Research of the US Navy, December 2008, 91.

19. The Ottawa Treaty prohibits the use of antipersonnel mines and, more generally, any weapon system that is unable to distinguish between combatants and non-combatants.

20. Clauden Barrois, *Psychanalyse du guerrier (Psychoanalysis of the Warrior),* Paris: Hachette, 1993, “Pluriel” collection, chapter VIII.

21. Georges Chapoutier and Frédéric Kaplan, *L’Homme, l’Animal et la Machine (Man, Animal and Machine)*, (Paris, 2011), 122.

22. Chapoutier and Kaplan, *L’Homme, l’Animal et la Machine,* 123.

23. Quoted in Singer, *Wired For War,* 211.

24. For the dynamics of the innovation process in the Armed Forces, see Stephen P. Rosen, *Winning the Next War,* Ithaca and London: Cornell University Press, 1991, Part 1. See also Barry R. Posen, *The Sources of Military Doctrine. France, Britain, and Germany between the World Wars,* Ithaca and London: Cornell University Press, 1984.

25. Peter W. Singer, *Wired for War,* 192-194.

26. Pascal Vennesson, “La guerre sans le peuple?” (“War without the people?”), in Frédéric Ramel and Jean-Vincent Holeindre (dir.), *La fin des guerres majeures (The end of major wars),* (Paris, 2010) 213.

27. Pascal Vennesson, “La guerre sans le peuple?” 215.

28. P. W. Singer, *Wired for War,* 343. Developed by Gen Charles Krulak of the US Marine Corps, the notion of “strategic corporal” relates to the idea that the action of a simple soldier may have repercussions on the entire strategy.

29. Commandant Damien Rouillé, “Les robots au combat, une révolution?” (“Robots in combat: a revolution?”), *LeMonde.Fr,* 21 December 2010.

30. Commandant Frédéric Fayeux, “Terminator versus Talibans”, *Défense et Sécurité Internationale* (International Defence and Security), April 2010, No. 58, 76-79.

31. On this question, see Karl-Heinz Frieser, *“Le mythe de la guerre-éclair. La campagne de l’Ouest de 1940” (“The myth of the Blitzkrieg: the Western front campaign of 1940”),* (Paris, 2003).

32. P. W. Singer, *Wired for War.* 343. See also by the same author: “Wired for War? Robots and Military Doctrine”, *Joint Force Quarterly,* No. 52, first quarter 2009, 104-110.

33. Edward Luttwak, *“Le grand livre de la stratégie”* (“The big book of strategy”), (Paris, 2002,) 67-68.

34. Martin van Creveld, *Technology and War: From 2000 B.C. to the Present,* (New York, 1989), 220.

35. Stephen P. Rosen, *Winning the Next War,* 243-250.

36. Camille Rougeron, *Les enseignements aériens de la guerre d’Espagne (Aerial lessons from the Spanish Civil War)* Paris : Berger-Levrault, 1939. Quoted by Lt. Marie Bubenicek, in “Les 100 ans de l’hélicoptère. Perspectives” (“100 years of the helicopter: perspectives”), *Air actualités (Air news),* No. 604, September 2007. 40-41.

Chapter 3
Robots, Cyber, History, and War
by Mark Hagerott

Introduction

The world is on the cusp of a profound event in history: the creation of the lethal, autonomous robot.

Such time as this requires clear thinking, for the emergence of the technical possibility of Lethal Autonomous Robots (LAR) creates a paradox that NATO nations cannot escape. On the one hand, our potential enemies will most likely develop certain types of the lethal autonomous robot, that if NATO has not done likewise, the resulting capability gap put us at a military disadvantage and our security at risk. On the other hand, if NATO nations develop and then allow the export of certain types of lethal autonomous robots to repressive regimes, some of these recipient countries can use LAR against their civilian population, the result being human rights violations on an historic scale, an abuse made possible by advanced NATO nations. Policy makers and military officers must confront this paradox and seek a way forward.

As policy makers and military officers approach the paradox of LAR, historical context and a new framework for thinking are essential. It will be argued that the emergence of LAR is part the larger historical evolution of technology. Over the past several thousand years the development of technology has created three realms of warfare: the Social-Human, the Integrated Realm of man-machine, and the Machine Realm.[1]

As military officials come to understand that historical processes have created three realms of conflict, and that all military development and employment decisions can be situated in one or more of the three realms, than greater resolution of the paradox of LAR becomes possible. Placed in the framework of the three Realms, it is possible to navigate the paradox, to see how it can be urgent that NATO develop LAR designed for machine to machine combat in the Machine Realm, but at the same time, proceed with great caution the development of LAR designed to operate against human populations in the Social-Human Realm of conflict. Moreover, the possibility that cyber operations and cyber hacking can corrupt the algorithms of these unmanned electronic control systems argues for early, careful thinking on the subject. We turn now to better understanding what are the three realms, and how did they come about over the course of history.

Historic Evolution of Warfare: Three Realms Emerge

Over the past 1000 years, technological advancement has created three Realms of conflict and war. War began exclusively as a human activity (the Social-Human Realm) perhaps as long ago as the rise of agriculture, several millennia ago. To be sure, humans used and will continue to use technology in the Social-Human Realm. Possessing and creating technology is partly what sets humans apart. In the early years of warfare in the Social-Human realm, tools were rudimentary and human wit, will, and strength determined the outcome of battles. The Social-Human Realm still exists, and will exist as long as human societies remain, but it is no longer the only realm of conflict. Over several centuries the tools of war became progressively more machine-like and important to the battlefield, and in the process created an integration of man and machine, what can be called the Integrated Realm of conflict.

While the rise of truly integrated man-machine warfare (Integrated Realm) did not happen instantaneously, at some point the density of man-machine integration became strategically significant. When military operations entered this new realm cannot be pinpointed precisely, but the new realm had certainly emerged by the 16th century in warfare at sea. A candidate date the emergence of the new realm is 1588 in war at sea between Spain and England, when the integration of man and his complex machine created decisive advantage on the battlefield. As a study of history shows, a mere half generation earlier, integrated man-machine systems were not as decisive: men fought men, hand to hand, even at sea. In 1571 the 'Christian' fleet turned back the Ottoman fleet in the Battle of Lepanto, fought for the most part on galleys jammed with soldiers who surged back and forth across the tangled decks, killing their opponent man to man. It was to be the last massed, human-infantry, muscle-powered galley battle at sea, a form of Social-Human massed warfare that had lasted almost 2,000 years. A mere seventeen years later in 1588 a new realm of warfare emerged, the Integrated Realm of man-machine at sea, the realm of close integration of human technical experts and their gunpowder-powered machines, but only one of the two opponents adequately prepared for the change in 1588.

When the Spanish set sail against England, they planned to fight man to man: their Armada was jammed with approximately tens of thousands of Spanish soldiers who waited to grapple, board, and then kill or capture the Englishmen. In contrast, the English perceived the change in warfare and adapted their ships and warfighting doctrine to artillery duels at sea, and then trained for what became a running gun battle. And, the English adaptation was a decisive break with the past: they embarked few if any soldiers to counter the Spanish infantry hordes.[2] Sea combat had entered the Integrated Realm of warfare at sea, where close integration of man and their machines would prove decisive. English ship handling and longer range cannon enabled the increasingly specialized artillerymen to kill masses of Spanish infantry as they stood on their own Spanish decks, men who never did grapple "man to man" with the English.

The closer integration of human and machine continued to accelerate in successive centuries after the Armada of 1588. Ships were no longer measured by how many soldiers they could carry but by how many guns. The multi-gun decked "Ships of the Line," became the forerunners of battleships that would duel at Jutland. On land, soldiers began to integrate more closely with their gun, muscular archers giving way to artillery specialists who, by the later 1800s, dueled almost out of visual range. The gun became synonymous with the machine (think "machine gun"), operated by a specialist, the "machine gunner." In the First World War, in an effort to reduce the wastage of human life as soldiers advanced into the withering fire of machine weapons, the armored tank was created, an even closer integration of human and machine.[3]

The integration of human and machine in the early 20th century gave rise to whole new domains of warfare, those of undersea and in the air, where submarine sailors and pilots were valued primarily for their ability to integrate with and operate a machine.[4]

By the end of the Second World War and early Cold War, with the development of solid state electronics and computers, there began the creation of an almost entirely artificial realm of action, nearly devoid of human beings, the Machine Realm. However, until the development of advanced intelligence algorithms, humans had to necessarily pilot, and through data links control, the machines that fought and roamed the battle space. Possibly this year, in 2013, we will witness the first truly autonomous lethal machines that can patrol and maneuver without direct or extended range human control.

How to Think About Robots in Three Realms

Why will thinking in three Realms help solve the paradox of the Lethal Autonomous Robot (LAR)? When approaching questions of military employment, most military writers have typically framed their thinking of the battlefield by dimensional space or physical domains: air, ground, sea, subsurface. Such a system of classifications indeed has its place, but is no longer sufficient to address new issues brought about by the potentiality of autonomous, lethal robotics. Recent literature on robotics has struggled with questions that cross dimensional (domain) boundaries.[5] Moreover, an analytical structure that is merely physical is incapable of framing the moral implications that are emerging in proximity to lethal autonomous machines.[6] Organizing our approach to war in three Realms not only frames an historical reality, but will help to clarify such thinking and help guide the resolution of the paradox: which robotic machines to develop urgently to ensure our security, and which robot programs risk human rights implications, and thus to delay production of these systems, pending further study.

The three realms can be depicted graphically, see Figure 1. At the top of the shaded areas is the Machine Realm, an environment that is more hospitable to machines than men (e.g., upper atmosphere, the open ocean, the sea bottom, cyberspace); at the bottom of the shaded areas is the realm of most social-human activity. The Social-Human Realm is that area of action where social considerations are central, and moral-ethical-political factors take on supreme importance (e.g., trusting an ally, creating alliances, behavior of crowds, perceptions of moral violation as at Abu Ghraib prison). In the Social-Human Realm, human communications and relationships are the most decisive factors (at least until such time as robots can become lifelike and perhaps impersonate humans, which seems a long way off and will not be discussed in this essay).

In the middle of the spectrum is the realm of mixed activity, the Integrated Realm where machine-human activity resides, where integrated machine-human systems are decisive factors in military operations. In the Integrated Realm, human activity is less social, and is more mechanistic and closely related or connected to manned machine operations. For example, the human specialist who fires his Stinger missile system against manned combat aircraft is operating in the Integrated Realm of warfare. While the operators of these machines are still human, by nature of their mechanical-military activity their death typically is associated with the neutralization of the machine platform, and thus carries less political-moral significance as compared to the Social-Human realm where, for example, the abuse of prisoners or the killing of street protestors can undermine governments or entire alliances.

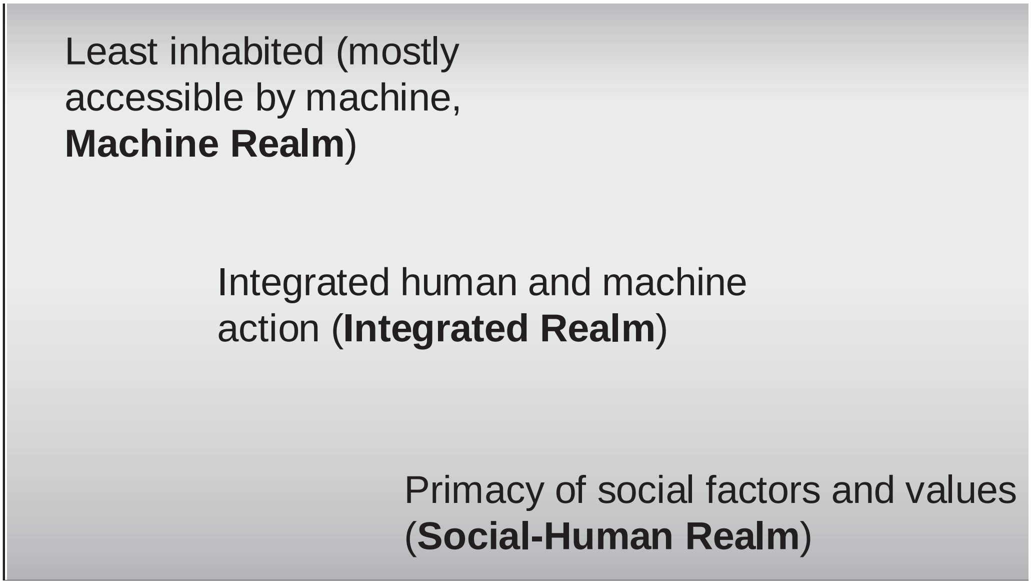

Figure 1. Three Realms of Conflict: Machine, Integrated, Social-Human.
Source: Created by Author.

The three realm framework helps put structure to what we know intuitively: the further away from Social-Human realm of action, the more appropriate, even desirable, would seem the employment of autonomous, lethal robots. But how so? An additional tool can help identify where lethal autonomous robotic development might be most productively directed.

Beginning with the first "Ships of the Line," combat capability began to be mathematically quantified in terms of machine characteristics, in ways still relevant to contemporary calculations of military power, and relevant to consideration of robots. The transformational warships of the 17th century were rated by the lethality of the iron shot they hurled at the enemy, a combination of the number of guns they carried and the weight of their broadside. They were also valued for their rate of fire (their speed of delivering repeated broadsides). Another measure of combat value was the delinking of operations from human input, the shift from manpower intensive galleys to more autonomous (labor saving and logistic saving) of wind powered sails. I would argue that these three characteristics, so important in the measure of the first complex systems, can be applied as a guide today when investing in robots. Where are the advantages of lethality, automation/ autonomy, and speed most valued? I would suggest that once again, the highest value is in the Machine Realm, not in a crowded, complicated Social Human realm. Let's explore this suggestion in more detail.

Robots in the Machine Realm

As noted previously, the Machine Realm is related to dimensional space that is typically unnatural or minimally hospitable to human habitation, e.g., the air, space, subsurface sea, open ocean, or especially lethal land battlefields such as would follow chemical-radiological-nuclear weapons use.[7] To operate in these spaces, increased automation or autonomy of machines takes on greater importance. Speed of operations is also a prime consideration in Machine Realm: given the increasing speed of advanced weapons, and complexity of machine combat systems, human reaction times may be too slow, and hence machines may dominate a region that might otherwise be habitable for humans. The higher speeds of microprocessors may be crucial to remain inside an enemy's OODA loop.[8] Finally, lethality is a key feature of the machine realm: machines are not taken prisoner by other machines, nor are they persuaded to 'give up'; machines typically strive for a 'mission kill' when employed against other machines. Examples of current military systems employed at the far edge of the Machine Realm include military satellites, anti-satellite weapons, submarine launched weapons, ground to air systems (such as the US Navy's AEGIS weapons systems and PHALANX in auto-modes), and military computer programs operating in cyberspace.

As shown in Figure 1, there is not a sharp line of demarcation between those regions that are solely the realm of machines and those that become Integrated. But our experience tells us such a theoretical demarcation is approximated in reality: there is minimal human habitation in space; little to no habitation under the sea; minimal human habitation of some deserts or mountain tops.[9] Interestingly, the surface of the sea is not an exclusive machine realm, and may not be as safe a field for autonomous machine operations as is subsurface or air systems. (The desirability for unmanned surface ships will be discussed later in the section on Integrated Realm). In general, then, operations in the Machine Realm enjoy a relatively large separation from the moral-ethical complexities of the Social-Human Realm. Being distant from the complex calculus that makes up human society, Machine Realm operations would be more mathematical and measureable. Thus, the employment of autonomous-lethal robots makes sound policy for operations in the Machine Realm, and as will be discussed below, is an urgent priority.

Machine Realm: Why is it Urgent to Develop LAR Now?

As recent American defense publications have noted, the United States and NATO are increasingly dependent on access to the global commons (the sea, space, and cyberspace).[10] Not coincidently, these global commons, which are strongly associated with the Machine Realm, should it become necessary to fight for them, will be fought to a large degree between machines. Thus, our capacity to win decisively in the Machine Realm is crucial to our security, and advances in robotics may well determine who can win this battle of machines.

In the "global commons," Machine Realm combat power will be determined to large degree by the ability to field systems with a premium on lethality, speed, and autonomy. Traditional measures of national power—often associated with nuclear warheads, population and Gross Domestic Product (GDP)—may be misleading, for these do not necessarily produce technologies with either speed or the ability to conduct lethal combat against other machines. The fact that the United States retains several thousand nuclear bombs provides brute lethal capacity to kill populations on a mass scale, but since 1945 have not been used precisely because their use resides predominantly in the Social-Human Realm, a realm fraught with enormous moral-ethical considerations. The figurative and literal "fall out" of these moral-ethical considerations have exerted a restraining effect on the use of nuclear weapons, and may do so in the future.

The ability to control commons may also have little to do with the size of a country's population or relative size of GDP. For example, in a contest to build advanced machines, NATO's large populations and huge consumption-based economies may mean less than a smaller economy with a robust robotics industry. Japan, a nation with a relatively small and aging population, and no nuclear weapons, gives the impression of a declining power. Yet, some speculate that since Japan possesses one of the world's leading robotic industries, she may in fact be an emerging military-technical robotic powerhouse. If a non-nuclear Japan can become a significant power in the Machine Realm, other nations may do the same. It may already be the case that the US and NATO are falling behind in Machine Realm robotics and be entering a period of strategic vulnerability.[11] Why would a robotic development create strategic risk?

A "go slow" approach in the Machine Realm could generate strategic vulnerability fairly quickly. History has shown that while Social-Human operations, such as insurgency and counter-insurgency, can take years to reach a decision, operations closer to the Machine Realm—involving large machines and advanced technology—often "break"quickly, even should one side gain only slight performance advantage. The battle of the Armada of 1588 was resolved in a matter of days, while the insurgency of the Spanish Netherlands lasted for decades in the 16th century. As Churchill famously observed, Admiral Jellicoe and his handling of his machines could have lost the war in a matter of hours, while the humans tangled in the trenches for four years on the Western Front without decisive result. Heroic naval aviators in the Battle of Midway in 1942 turned the tide of the war in a matter of minutes, during a single dive-bomber attack, while the Japanese ground campaign against Chinese conventional and guerilla forces lasted for a decade and ended in defeat. More recently, a more technically advanced Israeli air forced devastated the Syrian Air Force in a matter of days in the Bekaa Valley in 1982, while the social-human conflict in southern Lebanon continues to this day. The lesson: recent, long running land wars in the Social-Human and Integrated Realm are not a guide for war in the Machine Realm. Rather, slight differences between opposing systems in the Machine Realm can result in rapid breaks toward strategic failure or success. Thus the policy for LAR in the Machine Realm is compelling and consistent with history: build fast, deploy, innovate, and stay ahead of potential enemies.

Might Moral Ambiguities Slow Development of LAR in the Machine Realm?

A rushed development and fielding of advanced technology has sometimes been a source of strategic-politic miscalculation. In WWI, the decision to apply the newest of machines to war—U-boats—in the undersea attack on commerce was largely responsible for a moral backlash that led to US entry into the war, and contributed decisively to German defeat. The deployment of poison gas, machine guns, and long-range artillery against the manhood of Europe on the Western Front contributed to an erosion of human morale that led to mutinies in both the French and German armies and political collapse in the later. But the technical miscalculations of our grandfathers were rooted in a failure to understand the intersection of machine systems and social-human factors, which resulted in a counter-productive level and type of human casualties (e.g., non-combatant victims of unrestricted submarine warfare, the mass casualties of infantry in the trenches).

The employment of advanced robotics in an exclusively machine realm does not appear to risk the type of moral-ethical problems of WWI which undermined the attainment of strategic-political objectives. While voters and, by extension, politicians attach ethical-moral value to the treatment of the environment, animals, and humans, the same is not the case with machine systems (just think of the junk yards scattered across America, where automobiles once held dear by their owners are allowed to rust and decay with hardly a second thought!). Hence, the employment of robotics in the machine realm seem relative free of moral-ethical "down sides," and such machine systems should be developed with the greatest of speed and urgency without moral inhibition.

Robots in the Integrated Realm: Proceed with Caution

For operations in the Integrated Realm, situated closer to the Social-Human Realm of activity, the deployment of lethal, more automatic/autonomous machine systems quickly can become problematic. An example can illustrate the hazards of deploying highly automated and lethal systems in close proximity to social-human activity. The US Navy deployed a high tech ship (a ship designed to fight with high speed, autonomy, and lethality, in the Machine Realm by shooting missiles which would intercept Soviet Backfire bomber launched anti-ship missiles flying at supersonic speeds) into the crowded littoral region of the Persian Gulf in the last years of the Iran-Iraq War in 1987. The region was indeed a mixed environment of commercial ships, fishermen, commercial air traffic, and enemy gunboats. What turned out to be a moral-political defeat followed when the ship's AEGIS system was employed in the Integrated Realm of civilian air space without the benefit of a manned aircraft to confirm visual identification (ID) of human piloted aircraft flying at subsonic speeds. The use of this most advanced machine systems yielded mixed strategic results not because of the ability of enemies to defeat machine systems in a physical sense, but because of the ethical and ultimately political consequences of human casualties when the USS VINCENNES shot down an Iranian airliner.[12] This illustrated what, I argue, is intuitively obvious and can be seen as a truism: as the area of operations moves from an exclusively Machine Realm into a more Integrated and potentially Social-Human realm, the premium placed on lethality, autonomy, and speed will decline in relative value. In some cases, what were advantages in speed and lethality can become significant liabilities (e.g, the AEGIS automatic and lethal modes of operation, so important for defense against high speed anti-ship missiles become of limited utility in an Integrated Realm of mixed aircraft, civilian and military). As operations move yet closer to the Social-Human Realm, the relative value of lethality, autonomy, and speed are reduced even more.

A display of the declining value attached to lethality, autonomy, and speed is shown in Figure 2. The declining relative value is illustrated by reference to how the line slopes down from a high where the PHALANX weapon systems which relies on a combination of lethality, autonomy, and speed to defeat high speed anti-ship missile (ASM), to a lower position on the line where manned aircraft with "human in the loop" mode (a slower mode) which is typically sufficient to ID, divert, or, if necessary, engage enemy air vehicles. The key factors—a Composite of Lethality, Autonomy, and Speed—are assigned the acronym "CLAS."

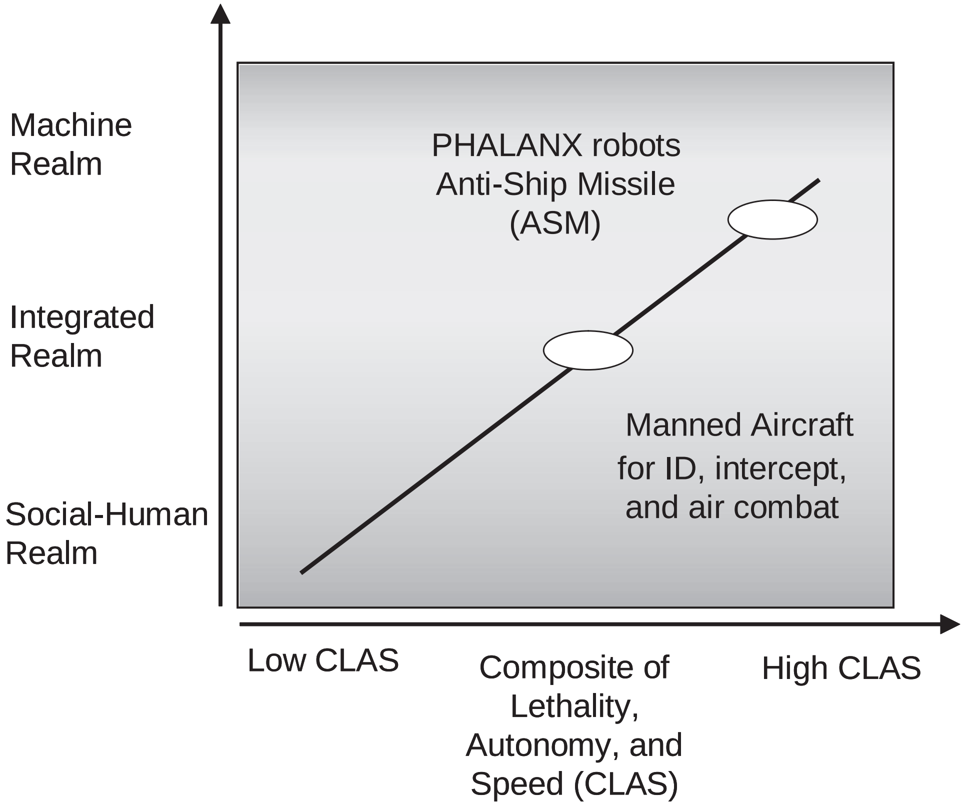

Figure 2. Technology Employment Curve.

Source: Created by Author.

The US Navy's early experience with the employment of autonomous, lethal machines has been paralleled or exceeded by the US Marine and Army units in the wars in Iraq and Afghanistan. While it seemed initially that the land wars in Iraq and Afghanistan would be concluded quickly, without the use of robots or drones, such has not proved to be the case. As these wars have dragged on much longer than initially expected, they have become the test-bed for increasingly automated systems. From the streets of Fallujah to the mountains of Afghanistan, military organizations have been compelled to employ a range of increasingly automated (if not quite autonomous) weapon systems. But to move beyond drones controlled by ground operators to the deployment of LAR is a huge step of significance for the future of war and the law of armed conflict. And to take such a step, or to hesitate, will not be easy, but will be fraught with moral significance. Why?

The decision to deploy or not deploy robotic systems on land can produce adverse moral-ethical consequences in two ways: the failure to deploy can result in higher casualties absorbed by our military; but the deployment of increasingly automated systems can result in civilian casualties which then erode indigenous support. Two cases help illustrate the tension.

In the first case, a decision not to deploy advanced, automated American systems would have led to higher casualties. American forces have since 2003 been subject to sporadic mortar fire in both Iraq and Afghanistan. The US Army developed a lethal, nearly automatic, and high speed response system that could shoot down incoming projectiles. The system, called CRAM (Counter Rocket Artillery Mortar) is similar to the Navy's PHALANX, and poses few if any moral-ethical problems, precisely because it operates very far from the Social-Human realm, and does not even seek to kill the enemy operators of the mortar, just the incoming projectiles themselves. The problem gets yet more difficult when an enemy wants us to kill humans for their own political purpose, and more automated machines can fall into a public relations quagmire.

In our second cases, Taliban forces in Afghanistan benefit from increased human suffering, and purposely plan for and provoke the employment of American machine systems with the hopes of collateral, civilian casualties. Senior US leaders appear to be aware of the problem, and are adjusting military doctrine to account for the adverse reaction to machine operations, and have restricted the use of standoff munitions even at the risk of higher American casualties.[13] The intuition of our generals and admirals, though their decision may have raised eyebrows since it increased the threat to our own soldiers, makes compelling sense when it is recognized that such machine operations had increasingly overlapped with the Social-Human Realm of action with counterproductive results.

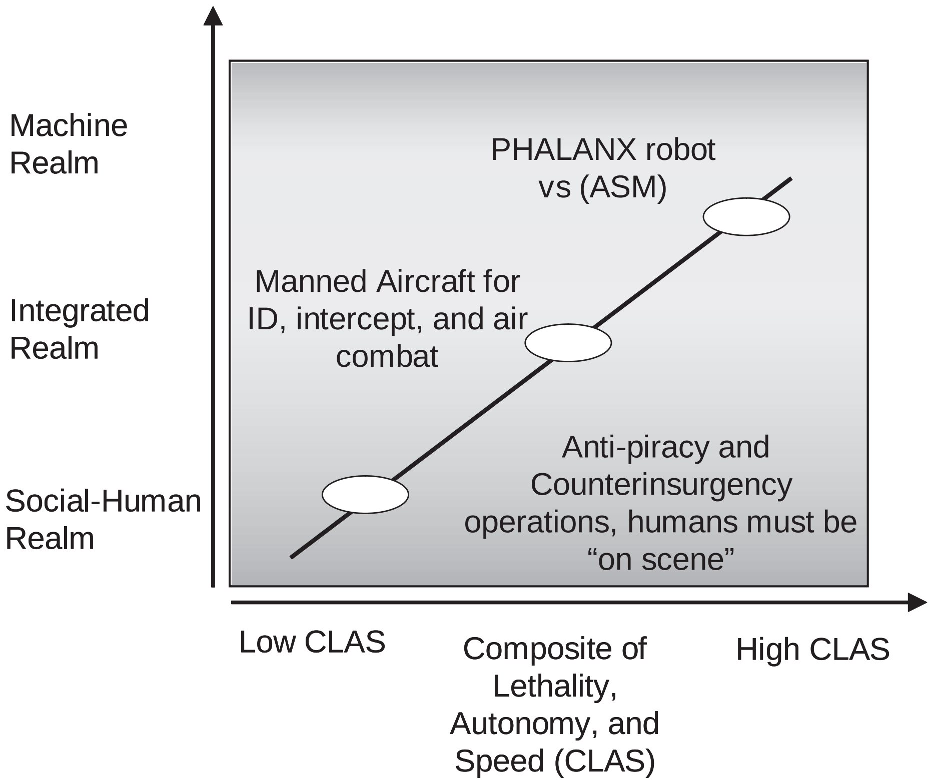

Figure 3. Complete Spectrum of Operations Across Realms.
Source: Created by Author.

Social-Human Realm Operations: Minimize the Employment of High CLAS Robotics.

As discussed earlier, the Social-Human Realm is that arena of action where a premium is placed on human interaction, human perception, human persuasion, and consequently human sensibilities of moral-ethical nature are most critical. In this realm, political-military operations are focused on perceptions of justice, on the problem of winning the “hearts and minds,” which is done best via human contact. In this realm the human is the tool of choice and high CLAS advanced machines are of limited use. The limits of technology can be illustrated when one considers an almost daily operation in Afghanistan or even at sea: the intercept and interrogation of persons who could be innocent civilians or suspected terrorists or insurgents. The limits of large, lethal, fast technology quickly become apparently. For example, while a supersonic aircraft or tank may be a powerful determinants in a battle against other machine systems, of what utility are these lethal systems when dealing with suspected terrorists on land or at sea? For example, terrorists hiding aboard a seagoing vessel or land vehicle well know the supersonic aircraft cannot hover and cannot lower a man to investigate them, thus this higher CLAS machine system poses little risk. In contrast, think how terrorists would react to the approach of a lower CLAS helicopter or a small gunboat embarking a boarding party capable of interrogating them face to face, human to human? It becomes a general rule that for Social-Human Realm operations, systems should be lower CLAS, low lethality, closely controlled by human operator who can exercise wisdom and discernment, albeit at Human speed!! But the significance of this general rule, because it is so basic, may have escaped the attention of policy makers in the war today.

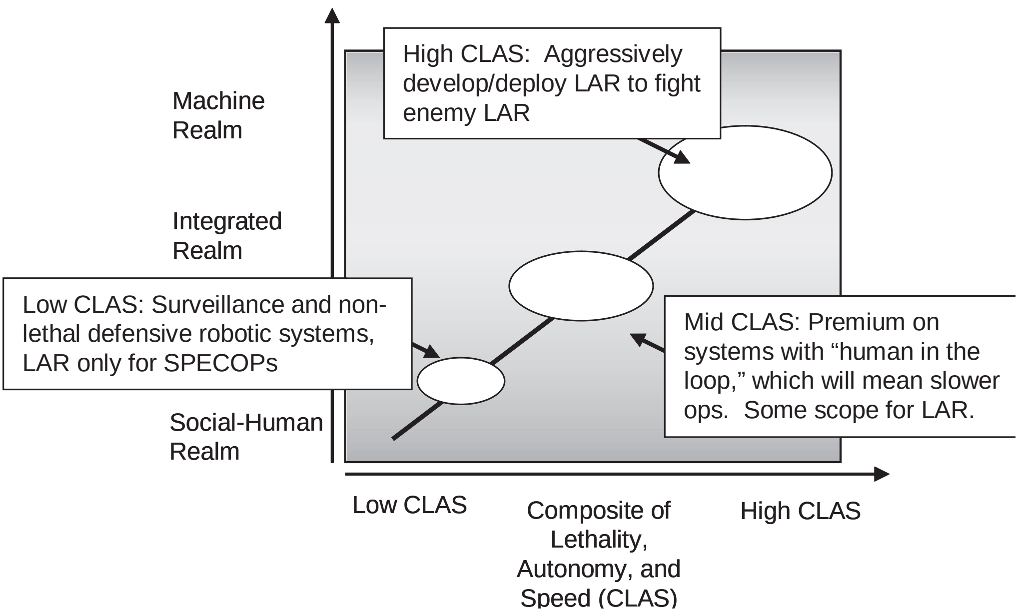

Figure 4. Implications for Robot Development/Investment.

Source: Created by Author.

In Pakistan and Afghanistan the use of unmanned systems and stand-off weapons may be complicating our efforts to win "hearts and minds." Some military thinkers in recent articles in military publications have questioned the compatibility of current drone doctrine and practice with the principles of population centric COIN.[14] On the other hand, those who support the current policy seem to imply that the Pakistani—Afghan discomfort with autonomous machines is culturally specific, and as the Afghans and Pakistanis become more advanced technological societies, their negative reaction to the deployment of our automated systems will fade. Perhaps. But the Pakistani-Afghan resistance to the use of lethal, semi-autonomous machines may be less culturally unique when we consider the rising chorus of questions in the Western press.

Human discomfort with autonomous systems originated in the West, in the high-tech cultures of Europe and United States. Beginning with Isaac Asimov and his path breaking work, *I, Robot* (1940), and for younger audiences, any number of dystopian "robot run amok" films, Western elites have been uncomfortable with the employment of machines against humans. More recently, the world's first robotics arms control society has not emerged in Pakistan, but in Great Britain. But the rising anxiety associated with drone strikes and robots now palpable in the West does not pertain to those cases where military organizations deploy machine against machine, or even machine against the operators of machines, but when the machines come too close to what we have described here as the Social-Human Realm: the killing of humans by a disembodied machine.[15]

Recent and ongoing operations seem to confirm that humanoid combatants or humanoid police will remain the tool of choice for governments when managing conflict in the Social-Human Realm. The most obvious real-world example is the ongoing counter-insurgency operations in Afghanistan, where NATO and Afghan National Army ground personnel must connect with and attempt to gain the loyalty of local populations. Advanced technologies, including the drones, cannot replace soldiers in this capacity: engendering loyalty is a social-human activity, shared between humans and not between humans and machines.

In general then, for operations in the Social-Human realm, there is no substitute for skilled human operators who, yes, may put themselves of risk. If there is a compelling need to deploy autonomous robots, then a premium must be placed on non-lethal technology. In the civil setting, the US Department of Justice is already moving in this direction, with research focusing on non-lethal, disabling technologies.[16]

Pondering the Cyber Implications of Unmanned Systems

This paper would be incomplete if it did not reflect, however briefly, on recent developments in the emerging field of cyber operations and hacking. The larger public has now become informed of details concerning the first ever cyber attack that resulted in large scale physical damage to a significant system: the STUXNET attack on the highly protected Iranian nuclear processing machinery, an event which was followed by the assassination of one of the targeted system's computer scientists who was attempting to contain the virus. In addition, a high value American surveillance drone was allegedly hacked over Afghanistan and forced down, analogous to traitorous action in a manned aircraft. In the wake of these two developments, along with advancements in cyber techniques and technology, it has become increasingly likely that despite the best efforts to install "anti-tampering" counter measures in future LARs, single units or swarms of unmanned machines may become vulnerable to cyber attack and corruption of control systems. Such a possibility is cause for great concern for two reasons. First, whereas for the past sixty years US/NATO have suffered few if any traitorous actions by small unit commanders on the battlefield, the possibility now exists that unmanned platforms may be cyber attacked, with the result that such machines may in large numbers turn on friendly forces, a radical new milestone in US/NATO military history. Secondly, the possibility of cyber attack on unmanned systems may establish grounds to challenge the current ethical arguments that justify targeted killing by unmanned systems. Recently, arguments have been made that the use of unmanned systems in surgical strikes may be morally superior because they are more discriminating than human combatants and/or human manned systems.[17] But in the cyber contested battlefields of the future, where unmanned systems may be corrupted and thus become less discriminating than the unhackable human pilot, the weight of the moral argument may shift against the development of greater fleets of unmanned or autonomous machines.

Conclusion

We are in the midst of a technical revolution, perhaps the most profound in history: the emergence of the lethal, autonomous robot (LAR). With this revolution comes a paradox: NATO must develop LAR as quickly as possible to provide security for the alliance, but must at the same time strictly limit the application of these machines which might threaten human rights on an historic scale. Current thinking about warfare in physical domains is insufficient. Rather, thinking about warfare and conflict in three realms—the Machine, the Integrated, and the Social-Human—helps clarify the problem and solve the paradox. In the artificial Machine Realm NATO nations should aggressively develop, test, and deploy high CLAS robots, see Figure 4. But in the Integrated and Social-Human realm—realms that include insurgency in Afghanistan, piracy on the surface of the sea, or riots in the streets of unstable societies—creation of LAR should be carefully restricted. Is there a precedent for grappling with this paradox? In the 19th and 20th century, as the weapons of war grew more lethal, our grandfathers came together to attempt to set rules to limit human suffering, and eventually controlled the spread and number of weapons that threatened mass human suffering: poison gas, lead bullets, and nuclear weapons. Perhaps a new version of Geneva Protocol and Hague Convention, one that carefully considers the implications of lethal robots in the Social-Human Realm is now needed?

Notes

1. The initial concept of three realms of war was first articulated in a brief to VADM Art Cebrowski in 2004. These concepts were later published with my co-author, Mark Gorenflo, in 2006, in the US Naval Institute, *Proceedings*. See Mark Hagerott and Mark Gorenflo, “The Shifting Domain of War,” *US Naval Institute Proceedings,* October 2006, 38-43.

2. See E.B. Potter, *SEAPOWER, A Naval History* Annapolis: US Naval Institute Press, 1981, chapter one for a discussion of naval transformation from the classical to the pre-modern period. For a detailed discussion of Lepanto, see Roger Crowley, *Empires of the Sea* (New York, 2009). For discussion of 1588, see Garrett Mattingly, *The Armada* (New York, 2005).

3. For a discussion of the dehumanization of combat in the First World War, see Paul Fussel, *The Great War and Modern Memory* (New York, 2013) and Tim Travers, *The Killing Ground: the British Army and the Western Front and the Emergence of Modern Warfare, 1900-1918* (Barnsley, 2009).

4. For a particular insightful discussion of how pilots integrated and identified with their machines, and were valued by their particular machine association, see Mike Wordon, *Rise of the Fighter Generals: the Problem of Air Force Leadership, 1945-1982.* (Stockton, 2002) For a navy discussion, see this author’s dissertation, Mark Hagerott, “Commanding Men and Machines: Admiralship, Technology, and Ideology in the US Navy, 1899-1990.” University of Maryland–College Park.

5. For a recent attempt at moving beyond the limits of “domains” of air, ground, sea, and space, see Vincent Manzo, “Deterrence and Escalation in Cross-domain Operations: Where Do Space and Cyberspace Fit” *Strategic Forum,* December 2011, pg 2. www.ndu.edu/inss. Accessed 12 February 2012. See also “Embracing Autonomy,” by Caitlin H. Lee, in *Air Space Power Journal,* Winter 2012, 76-88.

6. Trimble, *Jane’s Defense Weekly,* 2006 as cited in P. W. Singer, *Wired for War,* (New York, 2009) 128, footnote. Related, see Thomas K. Adams’ idea of moving outside ‘human space’ in “Future Warfare and the Decline of Human Decision Making,” *Parameters* Winter 2001-2002, 58. The problem is that Adams implies decisiveness in war has shifted to beyond the human space (what is identified in this article the Social-Human Realm). I would argue that Adam’s a conclusion is too simplistic. Rather, technology must be developed in reference to the realm in which it will operate. Care must be taken that we don’t attempt a “one size fits all,” that machines crucial to success in the Machine Realm perhaps should not be employed in the Social-Human Realm.

7. Cyber-space is a realm of machines, a realm where machines sustain the space through which travels important information for use by both machines and humans. However, since the subject of this essay is robotic policy, discussion of cyberspace will be limited.

8. “OODA” loop refers to the US Air Force concept of Observe, Orient, Decide, and Act (OODA), developed by COL John Boyd, USAF, as he analyzed the performance of fighter aircraft and pilots in combat.

9. Depending on presence, lethality, and numbers of machines, physical terrain that would be thought as in the Social-Human Realm can instead become the near exclusive the realm of machines. This has happened in multiple cases, but some examples to illustrate include the emergence of “No Mans Land” between competing machine armies of the First World War, a region bombarded by the world’s largest concentrations of artillery, raked with machine guns, and poisoned with industrial gases.

10. See Michele Flournoy and Shawn Brimley, “The Contested Commons” in US Naval Institute *Proceedings,* July 2009.

11. P.W. Singer, *Wired for War,* 241

12. A mismatch of technology in what is can be considered the lower "Integrated" or upper "Social-Human" Realm can generate a strong political-moral reaction. This tragic example of using the most complex and lethal of machines systems in the transition area of Integrated to Social-Human Realm haunt US perceptions abroad, 20 years after the event. See Reese Erlich, *The Iran Agenda* (Boulder, 2007), 67.

13. Dexter Filkins, "Stanley McChrystal's Long War" *New York Times Magazine,* 14 October 2009.

14. Peter Matulich, "Why COIN Principles Don't Fly with Drones," *Small Wars Journal,* 24 February 2012.

15. In late 2011 and early 2012 numerous articles and even editorials of leading publications have questioned unmanned system development and employment, especially the US government's use of drone strikes against what are arguably legitimate military targets. Part of the reaction appears not based on the legality of the drone attacks, but the negative perception of morality of disembodied machines used to do the killing. As an example of growing agitation and confusion about drone use in the public sphere, see W.J. Hennigan, "Anti-drone protester disrupts conference on drones in combat" *Los Angeles Times,* 9 February 2012, reporting on protestors at a defense industry robotic conference.

16. See Office of Justice Programs, US Department of Justice, for discussion of less than lethal technologies under development, http://www.ojp.usdoj.gov/nij/topics/technology/less-lethal/welcome.htm, accessed 30 June 2009. See also "US Police Could Get 'Pain Beam' Weapon," *New Scientist,* Dec 2008. http://www.newscientist.com/article/dn16339-us-police-could-get-pain-beam-weapons.html, accessed 30 June 2009.

17. Shane, Scott, "The Moral Case for Drones," *New York Times Sunday Review,* 14 June 2012, http://www.nytimes.com/2012/07/15/sunday-review/the-moral-case-for-drones.html?_r=0, accessed on 1 February 2013. See also, Schmitt, Michael N. , "Autonomous Weapon Systems and International Humanitarian Law: A Reply to the Critics", *Harvard National Security Journal,* 5 February 2013, http://www.usnwc.edu/getattachment/d6f79610-c65c-4df1-919a-e60cc96f7bfe/Autonomous-Weapon-Systems-Repl-to-Critics-HNSJ.aspx, accessed 9 October 2013

Chapter 4
New Extrapolations: Robotics and Revolution in Military Affairs
by Christian Malis

Afghanistan, Iraq, Libya, and the Middle East, with the spasmodic war between Tsahal and Hezbollah and Hamas, serve as military laboratories where certain traits of future wars can be observed. If robotization is taken to mean the generalization of the use of robots in the battlefield, this is one of the major traits in this respect. Iraq was pretty much the birthplace of operational ground robotics. For the US Army—which for decades now has been at the vanguard of military modernization worldwide—winged, caterpillar, and wheeled robots have already become commonplace companions. Robots have become well-established in tactical processes and are now to be found at every technological level, from basic, robust, and consumable models to technological jewels that are the worthy successors of U2s, SR-71s, and so on.

The scale of the change can be seen in the figures. According to a recent Congress report quoted by *Wired* magazine, the US Air Force now owns 7500 drones. 40 percent of American armed forces aircraft are drones, their number having increased 40-fold between 2002 and 2010. The goal, set by Congress in 2005, of robotizing one third of the nation's air resources by 2015, appears to have been achieved ahead of time. In 2010, the USAF announced that it was training more drone operators than F-16 pilots. As far as investments are concerned, the Pentagon accounts for 70 percent of R&D and 61 percent of procurement within the United States, rising from $3 billion a year in 2008 to $6 billion in 2018. With regard to ground robotics, robots eventually represented the "third force" in Iraq (13,000 Packbots, 11,000 Ravens and 1000 Talons sold), behind regular forces and those of private military companies (for which estimates vary between 25,000 and 50,000 men).[1]

As early as 1920, in a paper entitled "Extrapolations," 16 months after the end of the First World War, the French Captain Mérat drew attention to "scientific progress in warfare and resulting military reorganization," heralding a tactical and strategic revolution with the advent of new "superior weapons"—aviation and tanks. Twenty-five years later, nuclear weapons also had their visionary in the person of Admiral Castex—the author of the prophetic *"Aperçus sur la bombe atomique"* (Perspectives on the Atomic Bomb) in the October 1945 issue of *Revue des Questions de Défense Nationale*, a harbinger of weak-to-strong deterrence.

Is it time for visionaries once again? The American academic Peter Singer seems to believe this is the case, and indeed stakes a claim to such a title with his most recent work, *Wired for War*.[2] In this short article, I shall attempt to put forward ways of thinking about the issue in terms of forward planning, framed in terms of the following question: *Does robotization of the battlefield signal a new revolution in military affairs?*

The notion of "revolution in military affairs" returned to the fore in the United States in the early 1990s, and is the conceptual forerunner of "Transformation." The mechanism of the American approach has been rightly criticized in that it tends to view military phenomena, which are in fact social phenomena, as mere appendices to technical changes. Jacques Sapir, for instance, argues that:

> Innovation takes on a revolutionary aspect due to its massive circulation and its capacity for destabilising long-standing relationships between individuals, the material world and society, and for forming new ones.[...] A revolution in military affairs is characterized, from a military point of view, by the need for radical changes to the structure and position of forces, the nature of the economic and social system underlying these armed forces and lastly the relationship between offense and defense and the nature of the general correlation of forces. The revolution in military affairs is therefore fundamentally situated at the intersection between technical, social and organizational innovation. It is not indicative of any mechanistic application of technical innovation to the other fields, because technical innovation is naturally a result of both economic and scientific progress and of transformations affecting societies and organizations.[3]

During the Second World War, Raymond Aron had already examined the sociological circumstances (with a correlation between the "military revolution" of 1940 and the "totalitarian revolution") to explain how the Germans, unlike their enemies, were able to make the most of technical progress to completely transform warfare.[4]

If robotization is indeed going to bring about a revolution in the war fighting business, it will be because it will lead to significant changes in the following three areas:

1. The relationship between offensive and defensive power and the nature of strategic balances.

2. The relationship between men engaged in combat, tactical doctrines and operational art.

3. The relationship between the population and defense systems.

It will come as little surprise to encounter the three elements of Clausewitz's "strange trinity" in this context. We shall examine each of them in turn.

Obstacles and Catalysts

However, before dealing with this issue, a preliminary question needs to be addressed: are robots not merely putting in a short-lived (though spectacular) appearance on the stage of war? Is the recent boom in robots not related to the particular context of two atypical counter-insurgencies in Iraq and Afghanistan? Is it not likely that we will soon see the collapse of the "robot bubble?" Firstly, it is worth noting that the same question could be asked with regard to another military phenomenon whose growth is linked to Iraq and Afghanistan—that of private military companies. A thorough examination of the major trends in robotization, in the form of obstacles and catalysts, can provide some answers to these questions. The following table offers an analytical presentation of these trends.

This paper will comment on just some of these elements. From a technical point of view, while artificial intelligence has for now fallen far short of its promised capabilities, it has made sufficient progress to enable relative operational autonomy during vehicle navigation, for drones and land-based robots alike. Command and control functions rely on data links. For both LOS (Line of Sight) and BLOS (Beyond Line Of Sight) mode, the constant increase in available bandwidth, for instance through the use of new satellite transmission frequencies (the Ka band) is allowing increasingly large amounts of image and video data to be transmitted. These are just a few examples. At the same time, a certain number of obstacles that may prove quite difficult to overcome need to be taken into consideration. For the field of robotics, one of these is the high degree of mobility required if the robot is actually to become a commonplace companion for soldiers, especially for expeditionary missions. Scene analysis is another: this may be critical in the case of armed robots and have considerable influence on the rules of engagement, as will reliability. In the field of naval drones, the obstacles relate more to submarine communications and energy.

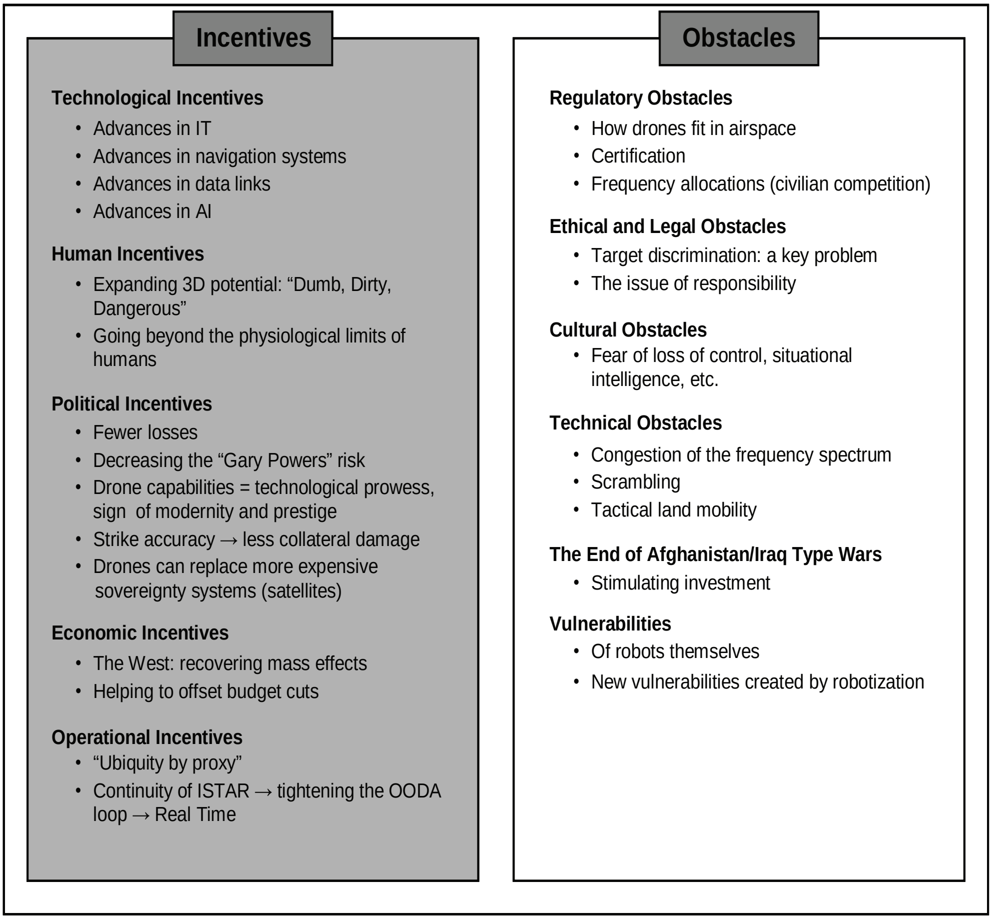

Figure 5. Robotization: Incentives and Obstacles
Source: Created by Author.

The register of political factors is seldom mentioned, but is also fundamental. In Western nations, the known sensitivity of public opinion to losses clearly weighs in favour of robotization. In Iraq, the small iRobot and Foster-Miller devices have led to a marked decrease in human losses, which could have otherwise reached Vietnam-like proportions. With respect to intelligence, in particular strategic intelligence, if a drone flying over a given territory crashes or is intercepted, this leads to far fewer diplomatic complications due to the fact that the local authorities cannot hold hostage, or indeed exhibit, pilots wearing the uniform of the power responsible for espionage. We refer to this as limiting the "Gary Powers" risk, after the American U2 pilot shot down by Soviet forces in 1960. This episode allowed Khrushchev to publicly accuse the United States and sabotage the Paris summit, much to the annoyance of Eisenhower. By contrast, the recent RQ-170 affair, in which an ultra-secret CIA stealth drone was intercepted and recovered by the Iranian army, did not give Tehran as much scope to make political capital out of the incident. Lastly, the possession of Medium Altitude Long Endurance (MALE) UAVs, which provide a sovereign strategic intelligence capability which may be seen as a low-cost alternative to the possession of spy satellites, has become an issue of prestige—a mark of technological and military modernity.

As regards to other obstacles, the key problem of target discrimination should also be reiterated: "there is too great a risk involved in entrusting the task of distinguishing targets or non-combatant military objectives from civilian property to UAVs," is the typical objection from lawyers.[5] This issue seems to affect the question of armed land-based robots more specifically (for UAVs it can be seen that is being resolved on a daily basis in operational practice by the Americans and Israelis, who use them to neutralize "terrorist" leaders); it is linked to the technical hurdle of scene analysis. Here too, any confusion resulting from an error of appraisal could, in the present-day context of "war amongst the people," easily be used by the enemy and create serious complications in terms of local and international public opinion.

We will leave the "horizontal" analytical approach there, since it is not a good means of identifying which trends which will end up taking over, and take a more summary approach. At the end of the day, in the medium to long term, it would appear that the blend of these various obstacles and catalysts clearly favors a continued increase in the robotization of armed forces. In this respect, we believe that the winning equation offered by robotization is as follows:

AUTOMATION=DIGITIZATION x PROTECTION x DOWNSIZING OF ARMED FORCES

A number of comments are in order. The automation of military systems is now an undisputedly general and long-standing trend, as has been noted by a number of military historians.[6] For example, it is now quite advanced with respect to a certain number of functions on board ships and in surface-to-air defense. Strictly speaking, robotization can be defined as the point, in terms of *both time and function, at which automation has been developed through to completion.* We have borrowed this definition from Admiral Sifantus.[7] This more technical definition supplements and refines our original definition of robotization as being the generalization of robots on the battlefield. Automation should be linked to digitization; with the help of communications science, digitization allows for the transmission of the large amounts of data gathered. We have already commented on the increasing importance of *protection,* a realistic incarnation of the former "zero death" doctrine. This argues in favour of anything that enables combat operations to be conducted remotely—a trend that is also longstanding. Proof enough of this is that since 2008, most *UOR* procurement for France (worth some €150 million per year) and the United Kingdom (€1 billion per year) in Afghanistan has been to meet ground force protection needs.[8,9] Lastly, the downsizing of the armed forces in large military nations is a major trend that is not confined to the West. In China, as indicated by the authors of *La Guerre hors-limite (Unrestricted Warfare),* the prohibitive cost of computerization and digitization may not have resulted in the abandonment of a "popular" mass army, but it has at least led to significant downsizing.[10] Similarly, the Russian Army is currently modernizing its forces (Russian President Vladimir Putin has just announced a scheme worth €450 billion) and constantly downsizing, having divided the number of troops by five since 1980 and halving them since 1994. Colin Gray also emphasises the trend towards "demassification of military force," so much so that 21st century armed forces will be distinctly different from those of the 20th century.[11] The accompanying reduction in the number of platforms involves preserving rare resources as much as possible—that of the manned system (the FELIN soldier being, in a sense, one such "manned system"), and *recovering mass effects* in order to be able to operate in the extremely large theaters that characterize a large number of present-day operations.[12] This results in the need to be "everywhere by proxy" and to have systems which are able to "replace us in these vast areas," i.e. robots.[13]

Strategic Transformations and Robotization

That point made, we can now turn to the question of how robotization is likely to affect power-based relations. Indeed, this is the first dimension of a "military revolution" that we wish to investigate.

By affecting military forces and the conditions for exercising offensive and defensive power, technical progress can cause considerable changes to the balance of power, as well as a reorganization of the strategic landscape. Thus in the 1930s, the "marriage of cannon and engine" (Raymond Aron) was, at least at first, an added bonus for land-based invaders, provided that they were able to implement industrial mobilization in advance. More recently, the spread of precision and information technologies, coupled with new operational concepts developed for the NATO-Warsaw Pact conflict in Central Europe, gave the United States a military superiority that was displayed to the world during the First Gulf War (1991), and described thus by General Gallois immediately following the conflict:

> Technically, the Gulf War innovated "war in the ether." The United States was in control from the very beginning of hostilities. It may be something of an approximation, but it can be said that General Schwarzkopf, in addition to his other titles, was also king of the airwaves. Within a huge pear-shaped area, the bottom of which encompassed Iraq, Saudi Arabia, the Red Sea, the eastern Mediterranean, southern Turkey, western Iran and the Gulf, and whose top reached up to 36,000 km above the earth and geostationary orbit, the coalition's electrons deafened, blinded, silenced and thus paralyzed the entire Iraqi military system. All that remained to be done was to flatten the entire country by means of air raids: these released as much energy as six "Hiroshimas"—and with better distribution of the destructive power—and were achieved with complete impunity. The silent, inoffensive, dense

and multifarious dance of American electrons was a huge innovation. It put the United States well ahead of all the other powers and set a lower bound for European nations, whether singly or indeed together, when it came to any military ambitions they might have.[14]

Within the next 20 years, a number of questions also deserve to be thoroughly investigated:

1. The first is the extent to which robotization could rejuvenate the American military leadership, in a similar fashion to what happened between 1990 and 2005. From "king of the airwaves" to "king of the robots?" In Kuwait City back in 1991, Iraqi soldiers waved the white flag when they noticed a US Marine Corps reconnaissance drone flying over their position. The USAF appears to want to move in this direction and is once again using revolutionary rhetoric in its plan for UAVs through to 2047.[15] In the light of the planned withdrawal from Afghanistan, the Pentagon wants to move on from counterinsurgency. The US President recently announced a new strategic doctrine in which the "Pacific pivot" becomes the new center of US attention and strategic effort. This paradigm shift puts drones in the pole position when it comes to investment priorities.

2. The second is to identify the new range of strategic options for the exercise of military force that will be opened up by robotization. The 1990s provided the image of the Tomahawk missile strikes demonstrating an ability to inflict unrivalled *military punishment* capabilities. The present-day equivalent is the image of armed *Predator* patrols above Pakistani tribal areas, punctuated by unexpected attacks decided by a reach back capability. In the future, certain "disruptive" countries could be subject to forms of *robot-imposed bans,* with their airspace, waters, or even certain land areas filled with fleets of robots embodying a permanent threat—in addition to the space borne inquisition that is already in action. The BAMS (Broad Area Maritime Surveillance) program can be given as an example: five drone bases will perform ocean surveillance to a range of up to 3000 nautical miles. Since "Augustine's law" also applies to naval units (Virginia-class submarines, Sea Wolf missiles, Littoral Combat Ships), it would indeed appear that faced with the expanding Chinese and Indian navies, the US Navy is seeking to return to a mass effect and 24-hour surveillance capabilities for sensitive areas (such as straits), for which it is calling on the use of robots.[16]

3. Due to the rise of potentially "revisionist" regional powers such as China and Russia that are eager to enforce, in their regional environment, the equivalent of the American "Monroe doctrine" laid down in 1823, America is likely to have to face a new state of play in terms of strategic power from the middle of the next decade onwards. This is particularly the case for China, against which America's future strategic system will clearly be directed. In this context, what use of more widespread, if basic, robotics could be made by major powers, or even regional powers such as Iran?

Robotics and Warfare

The current development of the use of robots and the emerging doctrines and concepts of use appear to present striking analogies with the original history of weapons—which ended up revolutionizing tactics. This has made a particular impression on Peter Singer, and he has expressed amazement at the gap he sees between the generalization of robots and the change in doctrines.[17] Most present-day military documents available set out to describe robots as support systems using existing tactics and operational methods. One such document offers the following insight into doctrine: "Robotics can be used to support land-based manoevers. As part of tactical action, robotics can greatly increase the latter's effects, either by adding to the range of capabilities already held, or by increasing the efficacy of combatants. Such integration could possibly involve altering methods of action and procedures."

Analyzing the military consequences of the Second World War in 1945, Pierre Gallois noted that the technological reasoning that had been at work during the course of the conflict obeyed two virtual laws of military history: the law of "revolutionary weapons" and the "law of formations." The first applied to the missiles and guided bombs used by Germany in 1944-1945 (V1 and V2). Although they were too recent and not yet mature enough to upset the conflict or reverse its outcome, he held that they had the potential for transforming future conflicts:

> *Typically, no weapon that is revolutionary in any given war is decisive in that war. However, it becomes decisive in the next war.*[18]

The second law—the "law of formations." Revolutionary weapons finally produce their effects only when grouped together into tactical formations. This can be seen with the Germans with their use of tanks and planes, but there are a multitude of examples in history, many of which were identified by the German military historian, Hans Delbrück. The Battle of Marathon and the Burgundian Wars in the 15th century illustrate the triumph of tactical infantry heavily armed with pikes (Greek phalanx, Swiss infantry). Generally speaking, we read that the main advantage of robots is to relieve soldiers of the most repetitive tasks (logistics, surveillance) and the most dangerous tasks (mine clearance, operating in an NRBC environment, etc.), to allow humans to concentrate on "what they alone can do." However, what could be more dangerous than *combat itself?*

Another characteristic of the history of military thought in the 20th century is that whenever revolutionary weapons came into being, a few visionary thinkers saw them as a harbinger of "transformation," describing this in prophetic works, often magazines or books aimed at the general public. Thus one of the most lucid, prophetic works on the transformation of fighting through the use of armed aircraft is that mentioned in the introduction, by Captain L. Mérat, in the March 1920 issue of the *Revue Militaire Générale*. In this forward-looking study entitled "Extrapolations," he sought to identify the transformations of warfare from a technical point of view, before moving onto the strategic consequences of these changes. He identified "superior weapons": those whose progress has considerable repercussions on the tactics for all other weapons. These weapons are the most "scientific" and usually the most recent. According to him, these were aviation and tanks, such that if weapons were classified from weapons of the future to weapons of the past, the following order was apparent: “aviation, assault artillery, artillery, fortification, infantry, cavalry.” The mass use of tanks, applied to the tactics of the strategic principle of mass, required attack formations to be envisaged, especially with a view to fighting against enemy tanks. Thus the armed forces had to reorganize themselves around the superior weapons, since these were the weapons that “set the tactical pace.” From this point of view, it is interesting to note that a military analyst as lucid as Ferdinand Miksche had predicted the transformation of combat modes as early as the late 1970s, in “PGMs are changing the combat picture” in 1978. Along the same lines, other visionaries could be quoted, such as Clément Ader and Giulio Douhet, who discussed the airplane and its strategic importance, or Bernard Brodie and Raoul Castex on the subject of nuclear weapons.[19]

As noted by Liddell Hart with regard to warplane formations, and by Pierre Gallois with regard to armed forces equipped with tactical nuclear weapons, these “new weapons” became the shock weapons, while conventionally organized forces (Second World War infantry divisions, Warsaw Pact conventional forces) took on the responsibility of occupying and organizing conquered territory. In the late Forties and early Fifties, the entire Western military community’s reflex was still to think of future wars along the same lines as the Second World War—a drawn-out war, expending millions of conscripted soldiers, calling on the entire industrial potential of the nations at war to produce huge quantities of weapons and resources. But from 1953-1954 onwards, Pierre Gallois predicted very short conflicts, in which due to the use of nuclear explosives the apogee of violence would be reached in just a few days; a small number of resources embodying immense destructive power; and a few hundred thousand career soldiers using the new weapons, without it being possible to call on the population and resources at large, due to a lack of time. A new, very different, explicit model replaced the “tacit knowledge” characteristic of a certain military culture. In doing so, he resembled those scientists who, in Kuhn’s words, can no longer ignore the anomalies overturning the established state of affairs in scientific practice and embark on extraordinary investigations; this finally leads them to a new set of convictions established on a new basis for practicing science.

Iraq, and to a lesser extent perhaps Afghanistan, acted as a laboratory for military robotics, just as the war in Spain did for “mechanical” warfare in the 1930s. As in Spain, and during the First World War, these new techniques did not yet lead to a thorough overhaul of tactical plans, even less so the overall strategy of the war. Like Guderian in the early 1920s, we have to imagine and “foresee” the *robotized wars of the future.* Industrially speaking, the usual pattern of pioneering start-ups can be observed—iRobot with its Packbot, Foster Miller with SWORDS and TALON—while the large groups are observing what is happening before moving into action (the British firm Qinetiq has bought out Foster Miller). It would also appear that the same phenomenon of a doctrine coming in on the back of technology can be observed. If the robot is indeed one of Captain Mérat’s “superior weapons,” at some point the other weapons will gather round these, with a renewed organization of the forces and tactical patterns. This phenomenon would appear to be at a more advanced stage in the air force, where the use of UAVs is beginning to replace that of manned aircraft for a certain number of missions. However, as will be seen later, this appearance could prove to be deceptive.

The forecast hypothesis could therefore be as follows: the use of unmanned devices in autonomous formations will thoroughly change combat methods, with combat contact tending to be increasingly entrusted to robots, and "conventional" forces (in their current form) being assigned to the occupation and organization of the conquered territory. In addition to the study of this new paradigm of warfare, there should also be an analysis of the future tactical patterns for the use of unmanned devices according to the criterion of tactical dilution, considering compact formations, swarming tactics and/or a mix of these two approaches. Experiments are due to take place.[20] All of this also supposes that progress is made not only technically, but also doctrinally and legally, towards drawing up a doctrine of autonomy. What is really at stake is to preserve three things: operational control, in the very interest of the mission (not betraying an avenue of progress, etc.); safety (avoiding possible "mistakes" with an out-of-control robot killing its own side); and responsibility.[21]

Imagine a scenario in 2025 in which Western land-based units have to enter an insurgent city to take control of it. They will use a "robotic screen" for the initial, most dangerous, contact. Patrols of reconnaissance/observation robots and teams of robots capable of remote fire—all of which are all semi-autonomous devices—will arrive ahead of the troops. All of these robots are semi-autonomous and capable of cooperative action. Their task is to "thin out" the situation before "conventional" forces intervene.

We are not yet at this point either technically or doctrinally. However, military research seems to be undertaking the construction of building-blocks to move in this direction. One example in France is the "ACTION" advanced research program (PEA) (heterogeneous multi-robot cooperation for ground/air control and maritime channel clearing missions).[22] In actual fact, the current development of the use of robots and the emerging doctrines and concepts of use appear to present striking analogies with the original history of those weapons that have ended up revolutionizing tactics. This has made a particular impression on Peter Singer, and he has expressed amazement at the gap he sees between the generalization of robots and the change in doctrines.[23]

Indeed, it would appear that robots represent a major step towards remote combat operations, potentially entrusted to formations of robots. Using robots, it might be possible to provide better protection of soldiers from the murderous combat of contemporary contact (IEDs, anti-tank rockets and missiles, artillery, individual weapons, etc.) behind a "cybernetic invisibility cloak." This is already the case with Foster-Miller's SWORDS which are operated by soldiers 500 meters to the rear. In this respect, robotics would be more revolutionary than digitization, altering "the traditional relationship of soldiers with their weapons and thus of men with warfare."[24]

The Timetable for Robotization

Is this hypothesis of operational forecasting consistent with the current discourse of the armed forces concerning robotics, and more specifically with planning, programming and R&D funding? To push the question further: what is the estimated date by which the French armed forces will have begun their "robotics transformation," meaning the development of missions using formations of robots for combat-related tasks?

In the event, in France the surprise could come from the navy.[25] Robotics can be seen to be making an appearance in new naval systems in two distinct ways in this presentation.

First, there is the generalization of naval robots. The multiplication of tactical drones for surveillance and minesweeping, as well as strategic drones for surveillance requiring a great degree of autonomy, constitute a future reality noted recently by Admiral Forissier in a speech in 2010, at which time he was Navy Chief of Staff: this will create a structure for the concepts of use; centers of operations to deploy drones will become targets.[26] Furthermore, we can note the extension of robotics as being a moment and function of a process of automation which is nearing completion. Today, automation is already very advanced on board ship: detection and tracking is automated and the unit is operated, along with the firing function by the celebrated CMS (Combat Management System). Automation is impacting other functions, too, such as supplies at sea. Although in the past the rule was for a high degree of versatility on a vessel, now and in the future it will be possible to perform a certain number of functions remotely using robots. This does not however involve complete robotization of naval missions. For those who are devising the Navy of the future and planning procurement, the challenge is to reflect the balance between human and technological resources within a system right from the design stage onwards. Bruno Sifantus suggests doing this by means of segmentation into four groups to enable an analysis of the confrontation between individuals and systems—decision-makers, operators, administrators and maintenance technicians, experts. Which groups of individuals would be needed in the system? Are individuals needed in intervention zones? Administration and maintenance can no doubt be extensively automated. Today the operator tends to be absorbed by the system. The system will not replace a DECISION-MAKER but depending on the case, the decision-maker may be placed elsewhere, leaving contact itself to robots. Unmanned underwater vehicles (UUVs) and unmanned "X" vehicles (UXVs) and their implementation are at the heart of this approach.

Counterintuitively, naval forces may play a pioneering role in the renewal of operational art based on robotics, followed by the air force and land-based forces. This is a summary view, but it has the merit of situating the different forces within a timetable, without any value judgement. However, it inevitably has the drawback of not mentioning special forces as such; these are often at the forefront and already use small, simple robots, as do special police units in France (RAID). For the sake of completeness, the picture should also include two environments with fully robotized structures—outer space and cyberspace.

Regarding air forces, based on the ONERA "UCAV systems" PEA project, combat drone formations could be used to support manned fighter planes (Rafale). This schedule is consistent with the Franco-British projects engaged, following the Lancaster House Treaty, for future MALE and UCAV drones. Initial operational capacity may be envisaged for UCAV drones by 2030.

The hypothesis of using formations of robots for tasks including combat is of course subject to the toughest possible testing on land, due to the previously mentioned technical obstacles. The present primitive nature of land-based robots in most known cases is striking. The French Army does not envisage taking a first step towards robotization (generalization or at least broader distribution of robots for a certain number of functions) before 2020, as part of stage 2 of the Scorpion project. Technically, although remote control has a bright future and the 'autonomy versus remote control' debate is probably fallacious, progress does need to be made on promising notions such as "adjustable autonomy." This concept currently represents a fair summary of the need to adjust automation and human decision-making depending on the situation. As far as bringing devices together is concerned, expected progress relates to the field of multi-robot cooperative work. A reasonable forecast for the completion of simple tasks would seem to be 2020. This, in any case, is the ambition of the PEA ACTION project for land-based de-pollution and maritime zone control.[27]

As can be seen, the prospects are further off time wise than for the other two environments. It seems that the future will involve soldiers "taming" robots, to make them their usual companions (the "accustomization" which apparently occurred in Iraq, between soldiers and mine clearance robots). The following step would be renewal of operational concepts—robot formations for advancing on the enemy, etc. Of course unexpected crises may cause this to develop more quickly. Clearly, the ways in which the land and its particular characteristics are very different from the other environments should not be forgotten: land is uneven, compartmentalized, heterogeneous and habited. However we can imagine that for certain functions, missions or weapons, robotics will be taken further. This brings to mind ALAT (French Army Light Aviation, with a command helicopter in charge of "robocopters," for example), and artillery. Two different scenarios can be imagined:

1. The human operator (e.g. a FELIN foot soldier) remains at the cutting edge of the tactical system but is surrounded by robotized auxiliaries and services (logistics, reconnaissance, mine clearance, unmanned or semi-robotized driving of manned vehicles, etc.), with adjustable autonomy.
2. Robots in formation are the contact system, with the human forces working behind them. This is the same pattern as the armored division in 1940 being followed by the 1918-style infantry. Technical forecasting and military sociology does not seem to allow for such a scenario before 2040.

Robotics, Arming of the People, and Society

A revolution in military affairs involves a change in relations between society and the national defense system. This is clear with respect to the revolutionary and imperial armies that emerged from the French Revolution, as well as the German Army of the Third Reich, made up of an increasingly large politicized army (the SS), and a conventional army whose combativeness and inventiveness had been boosted by the "totalitarian revolution" (Raymond Aron). Three aspects can be taken into consideration here: Western societies, enemy societies and the place of conflict in popular psychology.

To touch briefly on the first point, the advent of robots is to some extent in keeping with the traits of popular culture in the information society, such as the use of the Internet and mass circulation of video games. The *Predator* operator's cabin looks like a replica of an arcade game, while the control units for PackBots are deliberately based on commercial game consoles to make them easier for GIs to use. Let us however take a closer look at the potential relationship between robotics and society when it comes to the adversary.

When the resistance of the regular army is quashed, the only solution is, in Clausewitzian terms, the "people in arms." In some respects, for Western armies, Iraq and Afghanistan are analogous to Spain for the French Imperial Army from 1808 onwards: you are not defeated as long as you refuse defeat. As a last resort, armed resistance on the part of the population (or part of it) allows you to benefit from the intrinsic advantages of defense (knowledge of the terrain, solidarity of the population, trading space for time). A certain number of new features have already made use of modes of action based on individual action or small groups, as in terrorism and guerrilla warfare: rocket blitzes and advanced tactical missiles (anti-tank missiles used by Hezbollah), civilian communications and intelligence technology (satellite imaging, mobile telephony, GPS, etc.), and cybermobilization.[28]

Will the spread of robots further enhance the resistance capabilities of irregular forces and provide new assets which can be used for the "arming of the people" in "national defense" situations? As can be recalled, three years ago Hezbollah used basic Iranian-made drones against the Israel Defense Forces (Ababil, Misradl and Mohajer 4 drones). Questions may legitimately be asked about the scope for asymmetric use of a basic drone, along similar lines to semi-artisanal IEDs and rockets. Mini-UAVs resulting from "high end" modelling, small land-based robots used en masse and carrying explosive charges, or remote controlled submarines (already used by certain mafias to replace go-fast boats), swarms of small drones, etc. Asia, particularly China and Korea, has filed a great deal of patents for civilian robotics over the past few years. One may wonder if this area is not destined to become a hub for the proliferation of robotics techniques. All of this runs the risk of rapidly giving rise to the issue of export controls.[29] Japan has already suspended foreign sales of the Airmax mini robotic helicopter, originally designed for agricultural spreading.

A third non-negligible dimension is that the use of robots can have adverse strategic effects that neutralize tactical gains, if they serve to render the action illegitimate in the eyes of the local population—precisely where widespread "strategic wisdom" currently tends to see the true "center of gravity" of stabilization/counterinsurgency operations.[30] The emblematic case is that of the armed *Predator* strikes in Afghan tribal areas, fiercely criticized in this respect by one of the gurus of counterinsurgency theory in the United States, David Kilcullen.[31] The reactions of local populations may be likened to those of the "rearguard." Each "mistake" in Afghanistan leads to animated discussion in the Western blogosphere and social networks; the phenomena of cyber-arguments may need to be apprehended.

Conclusions

As recently noted by Jacques Sapir, as well as by Qiao Liang and Wang Xiangsui in *La Guerre hors limites (Unrestricted Warfare),* the downsizing of the military and the establishment of small high-tech professional armies over the past 20 years in the West, Russia and China, is also linked to the cost of modern "computerized" equipment, making it impossible to equip large numbers of conscripts.[32] Robotics cannot be disassociated from computerization and digitization. Communications science and networks are the vital interface for disseminating and using the data issued by all types of drones. In the long term, robotization completes and extends the transformation of automation and digitization, giving it a truly revolutionary turn. The extent of this transformation can quickly be seen by comparing the US Army in 2012 with that of 1970.

However, modern armed forces in which robotization is in progress are aristocratic armies. They can be compared to the heavily armed French cavalry under King Philip the

Fair. They may, as was the case in Courtrai in 1302, be taken by surprise by "villains" with no respect for the "normal practices of war," armed with basic weapons that are however effective against any enemy drawn into a land war. Robotization could allow Western-style armies to recover mass effects and truly fulfill the revolutionary promises of digitization. However, this phenomenon could benefit the enemy. In his study on innovation in the face of irregularity, P. J. Lassalle speaks of the "equalizing power of networks."[33] Should we be talking in terms of the "equalizing power of robots"?

Notes

1. Scott Gourley and Tony Skinner, “Robot Wars: unmanned ground vehicles” *Jane's Defence Weekly,* 3 June 2008.

2. P.W. Singer, *Wired for War: The Robotics Revolution and Conflicts in the 21st Century.* Penguin, 2009.

3. Jacques Sapir, in Thierry de Montbrial (dir.) *Dictionnaire de stratégie (Dictionary of Strategy),* 2000, 456 ; and *La Mandchourie oubliée (Forgotten Manchuria),* Le Rocher, 1996, 39.

4. Christian Malis, *Raymond Aron et le débat stratégique français (Raymond Aron and the French strategic debate),* Economica, 2005, 150-152.

5. Philippe Frin and Ronan Doaré, “La robotization du champ de bataille : enjeux et défis juridiques” (Robotization of the battlefield: legal issues and challenges), in *Défense et Sécurité Internationale,* special issue no. 10, February-March 2010, 34-36.

6. For example, Martin Van Creveld identifies four technological military ages and calls the most recent one, which began in 1945, the “age of automation.”Martin Van Creveld, *Technology and War.* Macmillan, 1991, 235-320.

7. Paper given during the PP30 symposium organized by the French General Armaments Directorate, on 10 May 2011, and conversation with the author in November 2011.

8. UOR = Urgent Operational Requirement.

9. Source: General Armaments Directorate.

10. Qiao Liang and Wang Xiangsui, *La Guerre hors limites (War without limits),* Payot, 2003.

11. *La Guerre au 21e siècle (War in the twenty-first century),* Economica, 2007, 186.

12. Fantassin à Equipements et Liaisons Intégrés = French Future Infantry Soldier System

13. General Desclaux, paper given at the “20 ans d'opérations aériennes” (Twenty years of airborne operations) symposium organized by the *Centre d'Etudes Stratégiques Aérospatiales (Strategic Aerospace Study Center), École Militaire (Military Academy),* 16 June 2011.

14. Pierre Gallois, “A la charnière des siècles, de bouleversements en turbulences” (“Upheavals and disruption at the turn of the century”), *Défense Nationale,* June 1992, 23-36.

15. Headquarters, United States Air Force, *United States Air Force Unmanned Aircraft Systems Flight Plan,* 2009-2047. http://www.globalsecurity.org/military/library/policy/usaf/usaf-uas-flight-plan_2009-2047.htm, 18 May 2009, (accessed 1 October 2011).

16. *Flyintelligence* AEGE, September 2008, 3-4.

17. Peter W. Singer, “Wired for War? Robots and Military Doctrine,” *Joint Forces Quarterly,* 52, 1st quarter 2009, 104-110, and his recent book, *Wired for War*.

18. Pierre Gallois, “Vers une stratégie décisive” (“Towards a decisive strategy”), *La France libre,* 1945.

19. *Military Review,* July 1978, 10-18.

20. C. Lundberg, Long-Term Study of a Portable Field Robot in Urban Terrain, *Journal of Field Robotics* 24(8/9) 2007, 625–650.

21. It is true that the USAF reckons that by 2047 it will be possible to give drones autonomy allowing them to act “within legal and policy constraints without necessarily requiring human input.”

22. For more information on this project, see http://action.onera.fr/.

23. Peter Singer, “Wired for War? Robots and Military Doctrine,” 104-110.

24. CES Velut, “La robotisation terrestre, défi technologique et défi humain” (Land robotisation: a technological and human challenge), *Check Point,* 8 August 2004.

25. We have made extensive use of the thinking set out in the presentation of Admiral Sifantus, military advisor to the DCNS group, previously quoted.

26. *Forces Navales 2020 (Naval Forces 2020),* a symposium organized by "Stratégie et Défense", December 2010.

27. For more information, see http://action.onera.fr/node/71, accessed on 15 April 2012.

28. Audrey Kurth Cronin, "Cybermobilization: the New "Levée en masse" *Parameters,* Summer 2006, 77-87.

29. Robert Sparrow, "Predators or Plowshares? Arms Control of Robotic Weapons." *IEEE Technology & Society Magazine 28,* no. 1 (Spring 2009): 25-29.

30. To tell the truth, this opinion is dubious.

31. Mark Mazzetti, "The Downside of Letting Robots Do the Bombing" *New York Times,* 21 March 2009.

32. Qiao Liang and Wang Xiangsui, *La Guerre hors limites* (War without limits), 81.

33. "L'innovation technologique dans les conflits irréguliers" (Technological innovation in irregular conflicts), in Christian Malis, Hew Strachan, Didier Danet, (eds.) *La Guerre irrégulière (Irregular warfare),* Economica, 2011.

Chapter 5
Robotization of the Forces and Organization of Army Units
by Jean-Philippe Wirth

Introduction

Objectively, the usefulness of robots for modern forces is no longer really questionable. They are progressively invading western military forces, especially those in the Iraqi and Afghan theaters where they are or have aleady been used owing to the many adantages they offer, in particular for the missions that the Americans call 3D: Dull, Dirty, and Dangerous. For the last ten years, the nature of recent conflicts and the imperative to preserve human lives have indeed led the various military forces to wonder about the place of robots and mini-UAVs within their forces. As of 2007, the American authorities have decided on this question by acknowledging its importance. They initiated ambitious programs planning to integrate robots within land forces as of 2015 to conduct new missions. At the same time, significant financial assets were commited to improve the robots dedicated to the so-called traditional missions such as Explosive Ordnance Disposal (EOD), a mission which currently concerns the majority of the robots deployed in the theaters of operations.

Though their integration is just beginning, an evolution has been perceptible since 2010 and it turns out that within the French armed forces, military robots will be much more numerous and complex tomorrow. Among them, the place of ground robots (UAVs included) is inevitably going to increase in the coming years, given the strong capability development potential of the domain. Indeed the proliferation of operational requirements is about to coincide with the maturity of available technologies. This situation therefore makes us think that the progressive generalization of the fielding of robots in units will take place soon enough to imply that we must think about it now.

Indeed, behind this near certainty, the integration of robots is an actual issue. The stopping of the Future Combat System (FCS) program and the evolutions of the Brigade Combat Team (BCT) induced the United States to cancel several envisaged programs. It can thus be useful to initiate some reflection on trends and on the consequences the robotization of land forces could have on the organization of the units.

Besides, in order not to repeat in the ground robotics domain the same mistakes made in the field of UAVs, an assessment regarding the interest and credibility of robotization options is imperative, since the SCORPION program itself is shaping the future of the French Army.

The Introduction of Robots Within Land Forces

In foreign countries, with the first lessons learned and the consequences of budget constraints, the current decade is a period when reflections on concepts of employment and on the integration of robots in military forces are deepening; this phase breaks with the wide-ranging developments conducted over the previous decade. Between 2000 and 2009,

Disclaimer: The views and opinions expressed in this article are those of the author and do not necessarily reflect the views or opinions of the French MoD.

many new robotized system concepts appeared, mainly in the United States. It is now clear that the motivations of the American government were based not only on the preoccupation of preserving human lives, but also on the will to find technologically-oriented answers to the new threats represented by terrorist organizations such as Al Qaeda.

Designed in order to produce quick lessons learned, some "pilot robots" have thus been deployed in Afghanistan and Iraq with a partly undefined employment. Therefore, they were usually not interoperable with the other systems used in the field. More than a dozen types of Unmanned Ground Vehicles (UGVs) have thus been tested, ranging from ultra-light robots (a few kilos) to robots designed to prepare the terrain (a few tons) and even robots that are armed. Other countries such as Israel have started developing robotized systems able to fulfil complex missions. These missions naturally resulted directly from the conflict with the Palestinans, like the surveillance of the urban terrain and searches of buildings.

However, the results are mixed regarding the new concepts of deployed robots. They have confirmed the importance for the soldiers to have a robot able to deal with new threats such as the IEDs. In that case, the remote operation of the robot is made most often within sight and at less than 200 meters from the combatant. But they also have highlighted the difficulty to implement systems able to fulfil less specialized missions such as reconnaissance or surveillance in a hostile environment. The main reason was probably the lack of maturity in the concepts of employment and in the sharing of roles between men and robots.

For France today, the robots deployed into theaters of operations outside national territory are exclusively dedicated to EOD-type missions, the framework of employment of which is clearly defined. But France is considering the wider introduction of military robots within its forces as well as their high potential for capability development. The place of robotics in SCORPION and the study of battlefield robotization initiated by the Academies and Schools of Saint-Cyr Coëtquidan reveal this recent evolution.

In that context, many stakeholders speak in favor of a comprehensive approach. They indeed think that it is the only approach likely to obtain the best compromise between parameters as varied as performances, weight, ownership cost, procurement times, readiness rate, flexibility of employment, ease of maintenance, lifetime of equipment, respect of the environment or the possibilities to recycle equipment at the end of their life. They also consider it as necessary to conduct reflections on the place of man in the decision-making loop and the sharing of tasks between man and the robot, in order to prevent the emergence of doctrinal or ethical reservations. Lastly, this approach seems to be the most appropriate one for the development of employment considerations, for the integration within the forces, and for the definition of an indispensable set of references which would be coherent with the SCORPION program. The organization of strength and equipment of the units in a structure matching their doctrine of employment, their operational training and their logistic support will have to be redefined in order to integrate the parameters linked to these new machines, namely the robots.

Let us nonetheless insist on the fact that a ground military robot has currently nothing to do with some uncontrollable android monster with iron eyes. It is today a discreet, smart, and docile small mobile device. And in the future, its shape with legs, wheels or flexible tracks could make it look like a pet or an unmanned utility vehicle rather than an extra-terrestrial humanoid.

Beyond the four identified priority missions, namely reconnaissance and surveillance, target identification and designation, counter-mining and counter-IED and CBRN reconnaissance, other missions have been identified for robots, both in the medium and longer terms. Current studies indeed lead us to think that robot systems will be involved in increasingly complex missions, thus requiring capabilities to adapt to the situation and to share information with other systems (whether manned or unmanned). This evolution will be made possible owing to the progressive breaking down of several barriers, not only technological ones but also legal and ethical ones, and will take place simultaneously in several directions:

1. Improvement of existing performances and systems for some given missions.
2. Improvement of the intrinsic capabilities of robots.
3. Extension of the missions and reconfiguration capability.
4. Invention of new concepts of robots.

It seems that, in the future, resorting to a robotized machine will be possible for nearly all missions. The concepts of employment of ground robots have therefore to be systematically integrated in considerations developed by many countries on the possible future formats of their military forces in order to face new threats.

All in all, relying on the lessons learned from recent conflicts, all the stakeholders of the domain agree to say that the introduction of robots in the forces is unavoidable. This introduction still has to be designed in terms of organization and its success will most probably depend on the progressive character of the fielding of the robots. However, this will necessarily result from a precise definition of their employment, from their acceptability by the forces, and from the evolution of technologies. By sharing the expected tactical advantages of their implementation, it is worth wondering about the evolution which can be induced by their fielding in the units in terms of strength, equipment fleet, collective and individual training and logistic support, in order to guarantee that they are fully integrated in the functioning of a unit.

Preserving the Human Potential

The first acknowledged technical advantage of the robot is that it improves the soldier's protection by making him/her less exposed to the danger. Though the robot cannot totally replace the combatant, it indeed carries the risk off-course for some actions limited in time and space. This thus induces an indisputable preservation of the human fighting potential.

For high-risk tasks like mine-clearing or CBRN reconnaissance, the current trend is to increase the performances of existing robots in order to limit, and even suppress human interventions. That is for instance the case for the AEODRS program in the US, aimed at developing tools with an unprecedented dexterity of the effect-producers in order to replace the human operator in the very dangerous phases of explosive ordnance disposal.

These hyper-skilfull arms, associated to "toolboxes," would be able to screw, cut, tear or unstick any piece of an IED in order to defuse it.

For all that, can we deduce from these expected performances of robotization that it is possible to downsize the unit engaged in a combat action? Beyond an automatic answer often given by some technocrat, the study of this question first and foremost requires a minimum of common sense. Even if it is eminently beneficial, the preservation of the human potential above all avoids having to renew it, given the necessity to systematically replace losses. It is obvious that preserving a life is an immeasurable and necessary deed. It also allows the State to avoid paying survivor or disability benefits. But this does not erase the need for the posting of the concerned soldier in the structure of the engaged unit.

The only direct impact of the actual preservation of human potential on the organization of the engaged force lies in fact in the possibility of adjusting the strength of the medical support necessary for the operation. This indirectly results in a decrease of the recruitment and training flow of the military personnel required in order to reconstitute the strength necessary for the good functioning of units. In other words, the following confusion has to be avoided: sparing lives means preserving the strength immediately available to fulfil the mission. But it does not mean questioning the need for the strength deemed necessary to fulfil the mission with a given item of equipment. Besides, the random nature of human casualties—limited as they are—will continue to imply that the training given to the combatant prepare him/her for the possibility of replacing his/her comrade or superior who would have been injured or killed, even if this case occurs fortunately less often.

In terms of organization of units, it is not the economy of human lives but the automation of the tasks to be fulfilled which can be the basis of a new assessment of the strength of the units equipped with robots. But this is not new. Artillerymen remember that in 1970 one commander and 8 men were required to fire the 155 mm gun whereas in 1990 one commander and 3 men were enough to use the modern and much more efficient automatic-loading version of the same weapon.

Moreover, efforts for optimization and automatization of tasks are continuously going on as, for example, the weight reduction which aims to facilitate their implementation and deployment in operation: the 25 kg Packbot robot, for example, has been reduced to a 12 kg model; and the 50 kg CAMELON EOD robot with a neutralization function has been transitioned to the 10 kg COBRA equipped with the same gun. Since their weight is reduced, the tactical and logistic transport requires fewer personnel. In principle, there would be an appreciable amount of economy of strength by systematically automating tasks fulfilled by combatants, in particular the heavy, precise or repetitive ones, since they consume a lot of time and effort. To deny this evolution induced by scientific progress and the human mastering of progressively elaborate technologies would be in vain.

The Possible Increase of Military Capabilities

However, robotization could destroy the framework of a too financial approach which would be strictly based on the number of capabilities to be held. The new technical-operational possibilities that robotization is going to progressively introduce can quickly lead to give up an "iso-mission" approach since they will sometimes make it possible to radically change the capability scale. It is the case for UAVs that flight altitude can be much lower than that of manned aircraft. The introduction of robots within land forces is thus going to unavoidably lead to doctrinal evolution and pave the way for the production of new concepts following an iterative course.

For instance, deploying a significant number of forces is currently the only way to correctly control the terrain of the area of action allocated to an infantry unit. In dismounted combat, a high number of combatants is necessary to engage on a long-lasting basis. In this type of mission, the strength often limits the extent of the area they are indeed able to control although it would often be needed to cover a much wider area.

In the future, it will become possible to employ many sensor robots without mortgaging *in situ* significant strength nor risking to dangerously spread it, and to therefore cover much wider areas by using automated relays in order to ensure indispensable communications. It will then be possible, not only to ensure the maintenance of our current capabilities, but also to reach a profitable increase of the latter in the various "robotizable" areas of activities. The improvement of these intrinsic capabilities and others should result from advances in the field of ground robots' mobility, power supply, security of communication assets, level of decision-making autonomy, and ability to cooperate with others.

The emergence of these increased possibilities will thus induce the following question: is the sought after goal just the optimization of strength, equipment, and organization of units so that they can fulfil the current missions only ("iso-mission" approach)? Or, is it worth extending a unit's scope of missions by exploiting the new possibilities offered by robotization?

Eventually, this issue of organization can be summarized in the following way: in the projected evolution of each system of forces, will the increase of the capability productivity induced by robotization only help return the investment back, or will it make it possible to reinvest the latter to procure additional military capabilities?

Regarding the engagement capabilities of units in the area of contacts, the study of "robotizable" actions over the entire spectrum of missions of the combined arms task force shows for instance that it is possible to increase the task force's capabilities in the field of intelligence by providing it with a much better vision of the enemy situation in contact and in short depth. The detailed knowledge of the tactical situation down to the lowest echelons would be a considerable improvement. In practice, it would enable the combatants to optimize the local conditions (moment, axis of effort, layout) of their maneuver and to notably accelerate the tempo of their engagement.

The capability to detect, identify, neutralize and, if need be, destroy a threat consisting of mines and explosive devices, by punctually using robotized machines has been developing for several years. But it is now possible to systematically strengthen the neutralization and destruction capabilities of existing systems while limiting human physical intervention. Seeking to complement the destruction capabilities of the combined arms task force with robots that mount direct fire weapon systems will undoubtedly require deep study. Their implementation against a human adversary indeed raises some ethical and legal questions and it would be counter-productive to leave them unanswered for too long. However, these robots—or effect-producers—could initially at least help apply some effects in the field, like opening a breach in a wall or destroying abatis obstacles.

Lastly, we unfortunately have to acknowledge the actual tactical handicap resulting from the individual combatant's combat load. This load is currently calculated at 50 kg—approximately 110 lbs; the historical average used to be 35-40 kg [77-88 lbs] or even more depending on the soldier's function, such as light-machine gunner or mortar crewman. In order to remedy this unavoidable problem, equipping forces with carrier robot systems seems to be an appropriate solution to this problem, be it MULE robots or exo-squeleton-type systems.

It is clear that the second proven tactical advantage attributed to robots is to make it possible to save forces by increasing their operational efficiency with the same number of personnel, relying on the material possibilities robots offer to carry actions away and to apply some remote effects. This enables the combatant to keep a stand-off distance, both in friendly and hostile areas. But this functional move can involve a shifting of the competencies requirements from less "know how to do" toward more "know how to control." It looks a little like what the outsourcing trend for some support activities has shown, a trend launched by the armed forces in order to refocus on the core of the combatant profession.

In the new context, the know-how will become less necessary than the "knowledge of how to have the job done." The training system will therefore have to adapt to this evolution of the need for new competencies by developing the ability of the combatant to control all the configurations of employment of the robot. This will be true for restoration of the robot's normal functioning mode or for switching it to degraded mode, the various steps of which will have to be designed ab initio. This process will also have to take into account the increase of automated intervention capabilities put at the disposal of the individual combatant while avoiding giving way to an over-specialization. The uncertainties and risks inherent to a combat engagement prevent clear compartmentalization of the competencies held by the various combatants deployed in the field.

The Probable Development of Combined Arms Cooperation

The robotization of land forces is undoubtedly likely to increase the operational efficiency of units, especially reaction time or the accuracy of their weapons. Initially at least, this improvement is going to concern mainly combat capability and the capacity of sustaining contact with the enemy. These changes will thus likely make the rules of deployment evolve, as well as the tempo with which units engaged in the first echelon are relieved. Fighting with the increasing help of militarized robots may even be likely to result in a progressive modification of the necessary balance between combat, command, combat support, and combat service support units.

As proof of that, let us just remember the effect that motorization and mechanization of French Army units had on the balance of the functions within its regiments and formations (brigades, divisions, Army corps) during the second part of the 20th century. Be it the adoption of the RC 80 structures (Leclerc MBTs) or the fielding of armored personnel carriers in the 11th Airborne Division, such evolutions—once called "cultural evolutions"—did have an impact on the organization, daily life, needs for specialists, collective training, ways to move, training conditions, maintenance of equipment, and the logistic support of the units concerned by these changes.

It is thus neither impossible nor unlikely that the ease of integration of robots in the digitized systems of the battlefield as well as their strongly sought interoperability will gradually reduce the current functional differences between branches. In which category of effect-producer will an armed robot be placed? More precisely, which criteria will we have to take into account in order to make such a classification, knowing that it is indispensable for the drafting of major organization documents (like an Order of Battle) which use precise references in order to define the composition of permanent formations as rigorously as possible?

Moreover, the guideline of land force robotization is the SCORPION program, the perimeter of which is defined by the equipment of the combined arms task force and its combat support. During two phases in the 15 coming years, a definite combined arms approach is going to lead the achievement of this “super-program,” the staff objective of which is organized around 3 capability axes: a unit’s equipment of course, but also its operational training and support system. The reference value of this approach will ensure the necessary coherence of the numerous items of equipment developed and fielded in the units. It will so naturally strengthen the de-compartmentalization expected between the various branches of an Army with a now very limited size.

Nonetheless, this innovative approach potentially tends to restore some kind of coincidence between the operational side and the organic one which used to prevail at the end of the 1970s but from which the organization of the land forces command had to progressively move away. It is thus a *de facto* proposal for the creation of units which would be “combined arms” in their conception, whereas until now the capacity to combine the effect produced by the units of different branches has been obtained by mixing units for a limited time depending on the expected length of employment. What we currently do, namely defining the composition of the force to be engaged on a case-by-case basis, could evolve in order to better preserve the natural cohesion of the standing units. The quality of their engagement in an operation outside the national territory would thus be better guaranteed or the operational preparation period reduced.

For approximately twenty years, the principle of unit force packaging has prevailed in the military management of the successive crises, in order to reconcile the requirements for performance of individual and collective training for each specialty, with the compulsory necessity to optimize the composition of the force to be deployed, and with the preservation of an overall strength always highly restricted owing to pressing political and financial reasons. The building of the Force to be deployed to the concerned theater of operation must be so sharply fine-tuned that it always induces a too subtle functional division in order to keep homogeneous standing units in each branch.

Since the non-conclusive experience tried during the 70s, there has virtually been no combined arms regiment on the national territory, but just some small units in the overseas departments and territories. The brigade is thus currently the first level of combined arms training for the various regiments or units of each branch. But tomorrow, the robotization of the forces might question this historical organization and lead to the progressive implementation of regiments organized around standing combined arms task forces. In other words, with bottom up doctrinal developments that the use of robots is going to naturally induce, starting from the lowest unit of employment and the announced spread of simulation practice inside the units, the development of the equipment modularity might also reduce the need for units modularity and even progressively replace it when force building is to be performed.

Modularity in the field of ground military robots has by the way been developed in France as early as 2003 with the “MiniRoc” upstream studies program which was aimed at designing robots able to both conduct multiple missions in urban terrain and be transported there by dismounted combatants. The solution adopted to achieve that was to develop the modular payload concept called “mission module” which makes it possible to configure the robot before each mission. Since then, this modular concept has been adopted by the Americans with an extension which has resulted in the notion of a generic command-control station. This approach finally led to the development of the Joint Architecture for Unmanned Systems (JAUS) standard which must guarantee the “intraoperability” of the 3 main components of the robot: its platform, its payload, and its command-control station. Incidentally, the arrival of middleware like the Robot Operating System (ROS) now reinforces this trend toward modular robotics.

In order to properly appreciate the advantages and drawbacks of such an evolution, knowing that various modularity levels can be envisaged, it will probably be necessary to assess various solutions for the robotization of the forces by integrating in particular the major following criteria: assessment of operational aspects, procurement and ownership costs, interest in terms of technological capitalization, increasing complexity of structures, possible loss of rusticity, and normalization process. Another way of organizing units, training them and consequently supporting them is thus emerging. Incidentally, the planned creation of a SCORPION Combat Center of Expertise clearly shows that such evolutions have to be studied in the upstream, by gathering the indispensable competencies in order to ensure that the adopted solutions are coherent.

The Acceptability of Robotization in Units

The third major advantage which can be expected from the irruption of robotics in the armed forces is the possibility to carry out many precise, repetitive and boring tasks. The permanence and regularity of performance, which are its corollary, will undoubtedly have significant consequences on the tactical employment and logisitic support of units. This simply shows that the implementation of such machines can have notable consequences on the living and working conditions of military personnel who, as professionals, are highly demanding regarding the quality of their tools.

The analysis of the acceptability of robots by various French Army units includes two major axes. The first one is naturally that of operational acceptability, but the second one is unavoidably the acceptance by the humans. The first approach consists in studying and validating the operating reality of the proposed systems in operational conditions, both in terms of technical coherence between the various implemented assets (transportation of platforms, readiness of sources of energy, variable nature of the terrain, ability to outclass the adversary) and in terms of abiding by the capacities and the operators' potential (effect on stress, size efficiency ratio, level of mobilization of attention abilities).

The second approach concerns the taking into account of human factors. Robotic systems are indeed new items of equipment and actually innovative ones, and their relations with humans must therefore be carefully analyzed. Besides the fact that the man/machine interface occupies an unprecedented dimension in the yet to be established relation, the use and doctrine of robot employment must take into consideration the specific place and role of this new collaborator which is as intelligent as it is unfeeling. The choice for a relevant strategy of unit robotization will depend on a detailed assessment.

For instance, the classification of military robots according to their weight has long been a key consideration. But, for a few years now, though the weight of a robot remains a fundamental element, the machine has rather been considered in terms of "deployability," since the mobility constraints are of course different if the robot can easily be carried by a man or not. A combatant can thus easily deploy it if the platform does not exceed 5 kgs (11 lbs), or it can be deployed from a vehicle and carried by one or several combatants if the weight of the platform does not exceed 30 kgs (66 lbs).

Innovations in the field of mobility over the last years are mainly due to the extraordinary development of Japanese humanoid robots. They bring with them new generations of micro-motoreducers and make it possible to elaborate polyarticulated robots. In the military domain, the most famous robot of this type is the "big dog" manufactured by Boston Dynamics, the major function of which is the transportation of supply in order to lighten the burden of the combatant. Today, the many limitations of this robot (robustness, weight, noise) do not permit its use in operations. Nonetheless, the current trend is to elaborate these "bio-mimetic" robots in the civilian field, which will unavoidably have consequences in the military one.

In the field of communications, robots usually require a very efficient radio link, in particular in high-speed teleoperating modes, in which the latency of the video sent by the robot should generally not exceed 100 milliseconds. In the coming years, we can expect an increase in performance. But it will naturally go hand in hand with the implementation of modes of decision-making autonomy making it possible to "cut," at least provisionally, the link between the teleoperator and the robot (this is indeed the most demanding type of link in terms of pass band and latency) and also to meet the requirement for more discreet systems.

The man/robot interaction is therefore of paramount importance because it is going to define the communication details between the man and the robot and "process" the aspects linked to the cognitive power of robot operators. There are indeed many underlying technologies since they include the robot command modes (like for instance speaking to a robot in a natural language), aid-to-decision systems, systems reconstructing the perceived environment or the modes of decision-making autonomy which make it possible to change the role and/or qualification of the operator (like for instance switching from a simple robot teleoperator to a robot fleet supervisor).

The general trend is definitely to try and reduce the cognitive burden of the operators linked to tasks that do not bring any added value to the mission. This includes the implementation of autonomous navigation modes, new multimodal interfaces such as the voice-activated control of a robot (as if it were a team member), environment reconstruction modes with relevant information for the mission, or a decrease in the number of teleoperators in favour of specialized analysts, etc.

The domain of decision-making autonomy linked to the mission is materialized by the ability of the robot to learn job-oriented behaviors, or to make an automatic decision (like taking cover if fired at or responding in case of attack). Though little research has been done until now in this field, it will certainly develop in the coming years. It will probably not be oriented toward a total replacement of human beings by robots which would require the application of new doctrine but rather toward the conduct by the robot of sequences of autonomous activity in space and time, like the simple missions that the commander of a small element deployed in the field gives orally or by sign to one of the executing personnel subordinated to him/her.

The Advent of Cooperative Engagement

Cooperative robotics is going to present a major interest since its areas of application are very broad, be it that of military operations or that of civil security. Its implementation will make it possible to significantly increase the efficiency of robots (including UAVs) which are still currently employed independently and which cannot hence benefit from an actual sharing of information. If we do not go further than the mere military field, this increased efficiency could undoubtedly provide several advantages likely to have an impact on the structural compositions of units.

Logically, it should be possible to further reduce the need for personnel necessary to serve the equipment. Today, two people are needed to control a robot: one who conducts it and the other one who handles its payload. In the same way, two or three personnel are necessary to ensure the mission of a flying UAV: the station chief, the pilot of the UAV, and the payload operator. The challenge of cooperative robotics is to envisage self-piloted systems, which would clearly be more autonomous. However, the complexity of the processes to be implemented in order to have actually autonomous platforms implies that this ambition will probably not be a technological reality within the next decade.

More prosaically, we are looking for solutions to help pilot the robots. Cooperation is going to permit the transfer, in the short run, of some controls from the operator to the robot. This is the case for robot convoys behind a manned armored vehicle, designed in the framework of the Robotic Followers Advanced Technology Demonstration (RF-ATD) program, or for the transport of a heavy load by several robots, achieved in the MARS program. In the area of combat, the lightening of the infantryman will certainly make it possible to increase his mobility in compensation for the increasing numbers of machines he will have the possibility to operate in the field. Able to remain longer far from his adversary, the combatant could have a range of machines on a following "shelf" in order to engage that adversary by combining their various effects. He will therefore have to manage these machines wisely, without letting himself be hindered by their number, since, in the end, it will not be the human capacities which will improve but those of these smart tools.

Cooperative robotics will also make it possible to increase the security and protection of forces. Today, a robot operator must remain some hundreds of meters from his/her platform because of the technological limitations of communication range. But the challenge is to noticeably extend the projection capacities of robotized systems. This result could be obtained by deploying a cooperative system, each element of which would participate in the communication network, which would allow the operators to get farther from the danger. It could also be obtained by watching the largest possible area with several agents, by equipping the ground robots and UAVs with power supply capacities, or by achieving tasks impossible without cooperation, owing to coordinated actions between the machines (like synchronized fires, validated and initiated by a human).

By organizing a platform specialization, cooperation will finally permit to improve the awareness of the tactical situation since the gains we could expect are an optimization of payloads and a reduction of the robots' complexity. The exploitation of the sensors' complementarities in the various bands (visible, infrared, acoustic, radar, etc.) would consequently make it possible to make the information more reliable and to produce a sufficiently elaborated synthesis so that man can fully exploit it.

That is why cooperation between men and robots on the one hand, and among robots on the other hand, must be as of now a major research axis within the robotics institutes and be included in staff studies. It will undoubtedly be an essential element to be integrated in the design of future robotized systems because it must also take into account the notions of cooperation between manned and unmanned vehicles, be they ground or aerial ones.

The distribution of roles will necessarily give priority to the ability of manned systems to produce effects on the adversary (like letting the robots localize targets and having man control the rounds fired by artillery launchers). The need for duality, which stems from the need for the conception or the organization of equipment to be fielded in units, will result in a technical constraint that will have to be integrated by considering it like an unavoidable compensation for the improvement of flexibility of tactical employment.

It is nonetheless worth noting that the implementation of a normative set of references dedicated to robotics remains pending since there is no standard at all in this field. Even the JAUS standard, which has long been unavoidable in the US, in particular in order to have generic control/command stations, seems to have been put on stand-by for several years. Oddly enough, even in the world of civilian robotics, the standardization approach does not seem to be topical. In the military domain, standardization agreements (STANAGs) are applicable for UAVs only. However, it seems likely that in the near future, the implementation of standards will become compulsory for military robots to guarantee their appropriate integration into force systems.

Quetioning the Equipment Policy

The emergence of new concepts for robots seems to be not only unavoidable but also desired. Beyond the missions currently carried out by human beings, which could already be performed by robots, a huge panel opens on new missions which could not be accomplished by humans until now, in particular when they were considered too dangerous or even suicidal. After the Chernobyl disaster, the Fukushima incident has just highlighted again the need to have (possibly consumable) robots available in order to intervene in hostile environments. The American Warrior and Packbot robots thus intervened there in order to measure the level of radioactivity. The new conditions of use and maintenance of equipment could thus introduce a sort of rupture in their design.

One can indeed wonder about the usefulness of armor and active or passive protection of the vehicles when they become unmanned. This should logically result in the adoption of less “militarized,” and therefore less expensive systems. The arrival of new civilian vehicles or “drive by wire” kits onto the market, for less than 20,000 euros ($25,000), must be taken into account when staffs reflect on the future of land forces. We can thus imagine the emergence of the following problem in the field of robotized equipment, be they remotely operated tomorrow or autonomous the day after tomorrow. Since there will no longer be any human operators to be protected inside of these vehicles, what will be the residual need for protection of these machines?

The answer which will have to be given will certainly imply taking into account the two following parameters:

1. The level of efficiency to be guaranteed in the fulfilling of the mission.
2. The financial cost of a possible loss or destruction of the robotized device.

Such are, by the way, the implicit foundations of UAV equipment policy.

Should we then privilege a traditional investment approach, consisting in equipping units with very sophisticated robots that are obviously well-protected but the cost of which will consequently limit the size of the fleet? Or could we envisage a new acquisition approach, choosing to procure a large number of robotized machines, which will indeed be less sophisticated, poorly protected, but for a significantly lower cost, possibly 10 or 50 times less expensive?

The acquisition costs indicated in Figure 6 are just given as examples. It is obvious that they are average figures and that they can vary depending on numerous factors such as integrated equipment, series effects, hardening for a given environment, synergies with productions for the “general public,” the emergence of new components or technologies, political orientations and decisions, among others.

That being acknowledged, knowing that the value 1 represents the top of the range of the deployable sensor, that is 5k€ ($6000), the third column gives an idea of the cost ratio which can exist between various potentially usable machines. It permits visualization of the impact of the choice of equipment type on the final costs and can thus orient the choice that has to be made between the various possible solutions. This comparison shows that the mass employment of mini or micro-robots may be more economical than the fielding of an inevitably limited number of heavy and complex ones.

In other deliberately more provocative words, one can wonder if the future of the robotized contact armored vehicle would not be the creation of a significant (several thousand) all-terrain vehicle fleet from the commercial range, which would be completely remotely operated, without any armor kit, equipped with a “low-cost” direct fire weapon and with some very efficient missiles? It would be somewhat comparable with a ground drone that we could easily take the risk to lose since there would be nobody on board, it would not be expensive, and since we would have many of them.

Robots	Price range	Relative Costs	
		Range	Average
Deployable sensor	from 0.5k€ to 5k€	0.1 to 1	1
Micro robot	from 15K€ to 25K€	3 to 5	4
Light mini robot	from 100K€ to 250K€	20 to 50	35
Mini robot	from 200K€ to 750K€	40 to 150	95
Heavy mini robot	from 600K€ to 1,250K€	120 to 250	175

Figure 6. Robot Acquisition Costs.
Source: Created by Author.

Of course, in the conception of future equipment, such questioning is not really new, though it has many consequences in terms of doctrine of employment, operational logistics, and maintenance. But robotization itself can substantially modify the "core" of the issue by breaking down the barrier of the indisputable necessity to protect the life of the personnel dedicated to the implementation of the vehicle. Consequently the need for protection which characterizes this vehicle would only be linked to the value of the items of equipment it would be equipped with in order to fulfil its role in the action. We could thus expect some form of rupture in the field of equipment and organization of units, even if this evolution takes place step by step given the progressive aspect of the fielding of new robotized generations of equipment.

The Need to Define a Robotization Strategy

In order to take into account the complexity of the challenge represented by the progressive robotization of land forces, and to ensure the permanent coherence of the progress that will occur in the many domains affected by this evolution, we will have to define the best strategies to be implemented in order to develop, procure, field, support, and renew the proposed robot systems. The chosen strategies will necessarily have to integrate the need to tightly link the achieved operational advances and the organic adaptations to be implemented.

In this framework, the strategies to be envisaged could be based on three major common principles:

1. The general and simultaneous development of all the functions, with levels of achievement (performance, maturity of technologies) increasing over time.
2. The development of each component or function following separate plans, with the drawing of some parallel axes and the definition of periodical updates.
3. The constant seeking of optimization of the various costs induced by robotization of the concerned function or domain.

The expression of operational requirements will have to include the definition of equipment priorities between the various functions for which possibilities of robotization have already been identified, such as intelligence, reconnaissance, static protection, communication relays, and target marking. But it will also have to astutely anticipate the long-term achievable actions.

One has therefore to expect specific difficulty from the probable impossibility of stabilizing the expression of these requirements on a long-lasting basis, as rapid and potentially divergent changes are going to appear. Distinguishing between short-lived infatuations and key improvements will be a particularly hazardous exercise as long as the prospective fog has not broken up, at least in any given area of such a transverse capacity domain.

The insertion of robots in existing or to-be-conceived systems and organizations will also have to integrate the impact of their fielding in the operating modes they will come with (simple teleoperation, assisted teleoperation, incremental development of autonomy capacities, progressive modification of responsibility-sharing, etc.). Indeed, the indispensable changes of unit structures will have to be studied and decided on in due time, both for what will pertain to the implementation and to the maintenance of these machines.

By the way, the utterly cultural dimension of these transformations will require a real process of acceptance aimed at users. In order to be employed at the highest level and to be efficiently used, any new system—*a fortiori* if it is brand new as will be the case for the robots—must be fully accepted at all the levels concerned by its implementation. Knowing that the slightest gap in this field is likely to result in a psychological rejection, the holders of the robot will have to fully appropriate each of them and they will have to be totally convinced of the added-value brought by its implementation.

To illustrate the cultural transformation that has to be conducted, we can mention the possible loss of relevance of the traditional expression "to serve a weapon or a piece of equipment." Indeed, though this expression is still aimed at highlighting the care with which this piece of equipment has to be maintained, keeping in mind that there could be no ambiguity regarding its use by the soldier, it could be different with a robot since the first requirement of the human operator will be to never lose his control and rather to assert his mastery.

Guaranteeing the developmental qualities of a robotized system will undoubtedly be another challenge. Because even in the case in which a rapid and massive introduction of one or several robotized systems could be envisaged, this fielding should neither result in closing one axis of development nor in going against the seeking of other future solutions which could be more interesting. The acquisition of experience and the capacity to exploit its feedback will have to be used not only to directly improve the fielded equipment but also to orient the studies or research applied to the development of new capabilities.

Lastly, the taking into account or the definition of legal constraints, and even the acceptance of the existence and employment of such new systems by public opinion, will have to be integrated early enough in the equipping process in order to avoid any potential inhibition. The objective will be to avoid civil-military duality between robotized systems which might induce some confusion regarding the legitimacy of their employment by land forces in their operations.

Having superiority over the adversary remains a fundamental requirement of combat. Just as it would be unnatural not to admit the notion of "endangering other people's life" in war, it would be deeply inappropriate to object to the robotized nature of these machines in order to limit their use—*a fortiori* to give them up—as long as the combatant keeps control over them and therefore remains fully responsible for their employment. It would certainly be astute to have this principle accepted and to decide on this issue as early as possible in the robotization process of the armed forces.

The strategy aimed at achieving it may usefully include the following main steps:

1. Have the direct users appropriate the equipment and gain confidence in the use of these new items
2. Gain experience by deploying and employing robotized systems in theaters of operations as early as possible
3. Progressively validate new concepts of employment and simultaneously rearrange current organizations in order to best manage the new proposed capabilities
4. Take into account as early as possible the interoperability constraints induced by the implementation of the various robotized systems
5. Integrate them into the planned developments in the SCORPION framework in order to benefit optimally from potential synergies
6. Exploit civil-military convergences which could be highlighted in terms of common requirements and components (like pre- or post-military intervention surveillance capacities)

For reasons due to the cycle of engagement of land units, to the tempos of technological advances observed in the concerned domains, to the average duration of organic command or responsibility periods and the multi-annual character of investments to be made, it seems astute to envisage a robotization tempo based on two to three-year cycles. Each cycle could then be built around three main axes:

1. A short-term axis which would include the implementation of available or very easily adaptable machines (intially remotely operated) as well as the organization of the corresponding lessons learned process
2. A medium-term axis focused on meeting the requirements expressed in the framework of SCORPION, along with a concrete objective regarding the operational fielding of a coherent set of equipment
3. A long-term axis aimed at preparing the following cycle, ensuring that the available technologies are mature (models or demonstrators) in order to match the expressed requirements (equipment specifications, training of personnel)

Conclusion

The significant tactical advantages offered by the robotization of the land forces in the next ten or fifteen years will certainly have consequences on the standing organization of Army units. Be it the increased selection for men in the production of the sought after effects on the adversary to gain superiority, or the still stronger contribution of equipment to obtain these effects, units are going to experience a natural and spontaneous evolution of their operating modes.

Their structure, their doctrine of employment, their training and their support will have to be adapted to this new configuration, and the "software" of their functioning will have to be reviewed. This transformation, which is already predictable, directly concerns the young military cadres who have just started their career. Before their third promotion, they will certainly have experienced stimulating robotization in the units in which they are going to serve. It is thus better to master it here and now so that they anticipate it, like they have been invited to do so during the seminar organized by the Center for Research at St. Cyr Coetquidan (CREC) on 9/10 November 2011.

Part Two

Robots and Soldiers on the Battlefield: a Challenge in Law and Military Ethics

Chapter 6
Stakeholders and Issues: Outlook for Change in the International Legal Framework for the Use of Military Robotics
by Éric Germain

The law may be considered to be a reflection of society: it is a transposition of changes, the fears arising from these changes, and the social need for protection that they entail. For instance, the upheaval of North American society in the 1960s is reflected very directly in the Quebec Criminal Code, with more new offenses created between 1965 and 1975 than during the whole of the previous one hundred years.[1]

In the years to come, it can be imagined that developments in civilian and military robotics will produce major changes in society which, in turn, will spark concerns and perhaps even fears, and therefore a demand from society for greater supervision through national and international law.

Investigation of these social implications cannot be carried out in isolation from an examination of the balances of power that, ultimately, will nurture fresh definitions in new legal frameworks. In order to anticipate the national, and above all international legal changes that will regulate the future developments and uses of military robotics, the forces that will influence the production of such laws need to be properly identified.

The concerns of institutional and industrial stakeholders appear to focus essentially on issues relating to capabilities and underestimate the importance of the social and legal implications—in both national and international law—which may be expected in the wake of this technological revolution.

Which Stakeholders Will Determine the Changes to the International Legal Framework?

Researchers who talk in terms of a "robotics revolution" insist on the scope of the upheaval to be expected, while recognizing the difficulty of measuring the implications for our societies with any degree of accuracy. For instance, Peter Singer draws a comparison with the birth of the automotive revolution. As far as robotics is concerned, he states that we are now at the stage of the Model T in the 1920s.[2] He argues that not only did the development of mass-produced cars lead to a new body of legislation (the Highway Code), it also completely transformed urban geography (with development of the suburbs) and led to whole array of social behaviors in North American society, which has even been described as the "car culture."

We can thus expect the development of robotics to influence not only social relationships, but also the philosophical, moral, and religious dimensions of our view of mankind itself. This ontology should be borne in mind as we turn our attention to the stakeholders in the

Disclaimer: The views and opinions expressed in this article are those of the author and do not necessarily reflect the views or opinions of the Directorate of Strategic Affairs, the MoD or the French government.

debate surrounding the issues of military robotics; it also explains the influence of religious nongovernmental organizations (NGOs) in the international ethical and legal debate.

Through their foundations and NGOs, Christian churches are already very much involved in the debate on military robotics. In 2009, the Roman Catholic Church relied on the *Institut für Religion und Frieden*, an Austrian military chaplaincy foundation, to investigate the issue of unmanned weapons.[3] Other faith-based stakeholders are committed to a considerably more pacifist orientation; these include the Fellowship of Reconciliation (FoR-England)[4] and the Quaker movement, whose Rowntree Charitable Trust sponsored the meeting of international experts held in Berlin in September 2010. This symposium in Berlin, to which we will return subsequently, marked a first attempt to coordinate the international campaign against remotely operated and unmanned weapons systems.

The fact that the collateral victims of essentially American and Israeli technology were located in predominantly Muslim nations meant that an increasingly significant political-cum-religious dimension to the debate on unmanned weapons was expected. In 2009, an initial example of this was *Amnesty International's* campaign condemning Britain's work on the engines of *Hermes* drones used by the Israeli army during Operation Cast Lead in the Gaza Strip.[5] The conclusions of the UN Goldstone Commission stated that along with governments and military actors, arms manufacturers should also be held liable in cases where unmanned equipment is involved in a disproportionate use of force.[6]

While the ability of non-governmental stakeholders (such as faith-based organizations) to mobilize public opinion should not be underestimated, the involvement of certain States to communicate on some ethical uses of military robotics should also be considered. As early as 2002, Iran highlighted the initiative by the Polytechnic University of Tehran to organize the very first international competition for unmanned anti-personnel mine detection devices.

The actors mobilizing public opinion exert lobbying pressure on governments to change national and international legislation, either through new laws or through changes in the way existing legislation is interpreted. However, there is a second level of action which relates rather to soft law. It is more particularly in the field of international law, which is not binding and not very normative in nature, that the direct expression of the sensibilities of public opinion is likely to find an ideal home.

This field of soft law should be increasingly taken into account when it comes to anticipating the new international legal framework for the use of military robotics. It is a complex field in which ethical, legal and political considerations are inextricably interwoven.

What Avenues for Changes in this Framework can be Envisaged in the Coming Years?

The change in the future legal framework regulating the development and use of unmanned weapons systems will largely depend on the ways in which opinion is mobilized around ethical issues. This means that it is vital to follow developments closely in the various forums addressing these issues, such as the International Committee for Robot Arms Control (ICRAC).

The ICRAC is an association of roboticists and academics engaged in the ethical debate on robotics (founded by Briton Noel Sharkey, Australian Rob Sparrow, German Jürgen Altmann and American Peter Asaro). From 20 to 22 September 2010, ICRAC organized a meeting of international experts in Berlin that brought together the main stakeholders in the international debate on the ethical and legal aspects of military robotics. Their primary goal was to promote the international regulation of remotely operated unmanned weapons systems such as armed drones. More radically, ICRAC sought to examine how a moratorium, or even a ban, could be obtained on weapons systems that could make the decision to open fire autonomously. These goals were ratified by a majority of the participants, although certain academics (Wendell Wallach and Colin Allen)[7] expressed a more nuanced position, and some even defended the legitimacy of reasoned development of robotic weapons (Ronald Arkin).[8]

Currently, the only agreement to mention drones explicitly is the Missile Technology Control Regime (MTCR)[9] which includes them in its definition of Unmanned Aerial Vehicles (UAVs or alternatively UAS, standing for Unmanned Aircraft Systems).[10] In this context there is also the 2002 Hague Code of Conduct against Ballistic Missile Proliferation (HCOC). When the treaty was under negotiation, some lobbying led to UAVs being excluded from its field of application. However, the criteria of the Hague Code relating to technical sophistication and control of the scope of action could well be extended to airborne drones.

Although it has been suspended since 2007, use could also be made of the Treaty on Conventional Armed Forces in Europe (CFE), in which it is interesting to note that the definition of the terms "combat aircraft," "combat helicopter," and "attack helicopter" (whether specialized or multi-purpose) was deliberately drafted in such a way as to describe a manned or unmanned craft.[11]

The field of international humanitarian law (IHL) could also be brought into play, with particular attention drawn to the possible implications for robotic weapons in Article 36 "New Weapons" of Additional Protocol I to the Geneva Conventions. In Berlin, the major concern related to the increasing degree of autonomy of robotic weapons systems leading to a transition from "man in the loop" to "man on the loop" and finally to humans being "out of the loop," i.e. not involved in the decision-making process.[12] Although the issue of armed airborne drones was much discussed at the Berlin meeting, the issue of humans being "out of the loop" was then more acute for ground rather than airborne military "robots."

The two most often mentioned examples were first, the South African accident in 2007 when an automated anti-air defense system's guns started firing horizontally, killing 9 soldiers, and second, the latest generation South Korean SGR-A1 robot. In June 2010, two SGR-A1s were tested on the border with North Korea.[13] This robot, developed by Samsung Techwin, has autonomous decision-making capabilities to open fire, making a breach of Asimov's first law of robotics a disturbing reality.[14]

Research into military robotics is conducted in the context of the law of armed conflict, which is still a singular law, outside the scope of ordinary law ("exorbitant du droit commun"). The first exceptional aspect is the military function, which allows the use of deadly force, within the State's monopoly on legitimate violence. This is an "exorbitant" power as defined by law and ethics. Although it is largely accepted in our societies that danger of death establishes a right to kill, the robotization of the battlefield is now likely to call into question this fundamental principle of the military function.

The example of the robotization of a military convoy may offer an approach to the issue in the context of armed conflict, as well as extending it to peace-keeping operations. The risk to civilians—children in particular—arising from the catch-up speed of a convoy vehicle is justified at present by the need to ensure the physical safety of the driver. How could this thinking be applied in the case of an unmanned vehicle?

The question can also be extended to ambulances or even robotic stretcher bearers. In the latter case, would such a robot be protected under the First Geneva Convention of 1949 (art.24), just like its human counterpart? The question is all the more legitimate in that attackers could make a case for action on the basis that the sensors required to run a robotic stretcher bearer could also be used to gather military intelligence. The example of a system whose non-combatant use and nature should not immediately pose any ethical problem demonstrates the complexity of the legal issues surrounding military robotics—issues which have not as yet been properly identified.

Robotization of the battlefield has the capacity to fundamentally change our appraisal of the law of war and international humanitarian law. The combination of technical, economic and operational factors is increasingly likely to lead to human beings being removed from the battlefield, and even from the decision process that determines whether to fire and the choice of target.

The number of accidental deaths caused by robots used in industry is now known, and it can be imagined that this number will not be any lower in the event of faults in military machines whose purpose is to use deadly force. In the future, the liability of the military or political stakeholders could be brought into play, as could that of the industrial designers of such robotic weapons.

The ethical and legal aspects are inextricably linked, but as yet they have not been sufficiently dealt with when considering our defense policy. A combined approach to ethical, social, and legal issues is undoubtedly a major strategic challenge for our nation, because to a large extent, it is they that will determine our future norms.

Notes

1. “Law and Society” *Canadian Encyclopedia*. http://www.thecanadianencyclopedia.com.

2. P. W. Singer, *Wired for War: The Robotics Revolution and Conflict in the 21st Century. (*Penguin Press, 2009).

3. The hearings of the IRF’s research program “Ethical and Legal Aspects of Unmanned Systems” led by Gerard Dabringer (who was present at the ICRAC meeting in Berlin) are available at http://www.irf.ac.at.

4. The FoR’s anti-drone campaign was led by Chris Cole (now heading up Drone Wars UK).

5. David Pallister, “British link with drone aiding the Israeli war effort” *The Guardian,* 9 January 2009. www.guardian. co.uk/world/2009/jan/09/armstrade-gaza. The United Kingdom is not the only nation that could have been incriminated according to the work by Patrice Bouveret at al., *Qui arme Israël et le Hamas? (Who is arming Israel and Hamas?),* GRIP, 2009.

6. The UN Human Rights Council report dated 15 September 2009 talks in terms of “war crimes” that could even be qualified as “crimes against humanity” with respect to the Gaza conflict.

7. Colin Allen & Wendell Wallach, *Moral Machines: Teaching Robots Right from Wrong, (*Oxford University Press, 2009).

8. Ronald Arkin, *Governing Lethal Behavior in Autonomous Robots, (*CRC Press, 2009).

9. The Missile Technology Control Regime (MTCR) signed in 1987 now has 34 signatory nations.

10. According to the terminology of the “equipment and technology” annex of the MTCR (11/06/1996), the definition of UASs concerned by the agreement “includes cruise missile systems, target and reconnaissance drones with capabilities exceeding a 300km/500kg range/payload threshold.”

11. See Article II, *Treaty on Conventional Armed Forces in Europe,* 1990.

12. This debate was launched by the publication of the US Air Force Unmanned Aircraft Systems Flight Plan 2009-2047 which mentions on page 41 the switch from direct human action in the decision-making loop to simple supervision “on the loop.” See HQ, *United States Air Force, United States Air Force Unmanned Aircraft Systems Flight Plan,* 2009-204, 41. http://www.globalsecurity.org/military/library/policy/usaf/usaf-uas-flight-plan_2009-2047.htm.dated 18 May 2009. Accessed on 10 October 2013.

13. “South Korea deploys robot capable of killing intruders along border with North”, *The Telegraph,* 13 July 2010. http://www.telegraph.co.uk/news/worldnews/asia/southkorea/7887217/South-Korea-deploys-robot-capable-of-killing-intruders-along-border-with-North.html, (accessed 10 October 2013).

14. Isaac Asimov’s First Law of Robotics: “A robot may not injure a human being or, through inaction, allow a human being to come to harm.”

Chapter 7
The Legal Aspects of Military Ground Robots
by Ronan Doaré

For many years, those studying military and political strategy have been taking an interest in changes in conflict and in particular what is known as irregular combat, and the involvement of private military companies (PMCs) in theaters of operations.[1] French legal commentators *(la doctrine)* are also examining, albeit more discreetly, the introduction of new military hardware, such as robotic devices, onto the battlefield.[2] The White Paper on Defense and National Security meanwhile stresses the development of high technology, especially on "surveillance and intelligence, both exo- and endo-atmospheric" (drones or UAVs), but also on "long-range precision strikes, including by armed drones."[3] By extension, and to meet the various remits of the armed forces, military ground robots are also the target of "major investment spending in research, development and acquisition." As a general rule, there are several reasons for using robots, mainly "Carrying out hazardous work (while limiting human exposure), increasing force effectiveness, and performing arduous or repetitive tasks."[4] The preservation of human lives appears to be a key driver, and it alone fully justifies the technological innovations that could lead to a "complete overhaul of the strategy landscape."[5] A 2006 report to the French upper house (Senate) on the functions of drones in armed forces stressed, in this way, that the role of aerial drones is "to overcome the constraints inherent in manned aircraft stemming, in the main, from the dangers posed to the lives of the crew and their physical limitations, while still benefiting from the specific advantages of aerial intelligence gathering."[6]

There are many questions raised by the development of military ground robots whether relating ethically to the relationship between man and machine or legally to the status of robots and the implications in terms of liability. Indeed, the deployment of robotic devices requires the legal framework to be determined as regards the use and control of hardware, the development of which opens up prospects as interesting as they are worrying. It is true that "against a backdrop of military strategy that is increasingly oriented towards the protection of human life, the systematic use of robots in the armed forces is arousing great interest."[7] The issue is complex because of the large number of parties involved (manufacturers, users who are by definition governed by a hierarchy and included within a chain of command, combatants, and civilian populations). Armed forces intervene under bilateral agreements or, more usually, multilateral agreements, under a mandate (from the UN, NATO or EU) although oversight by national and international courts is developing.[8]

Should new legal models be sought, such as liability for loss or harm caused by objects in one's care *(fait des choses)*, properly suited to encompassing the specific missions and risks inherent to the deployment of robots?[9] Or, conversely, should we content ourselves with applying existing legal provisions by taking the view that the use of robots does not alter the question of the division of liability in relation to the use of force and does not call for any major changes to the fundamentals of the various parties' liabilities if robots are deemed to be equipment?

For now, it must be admitted that "unlike air forces which are equipped with attack drones, ground forces remain reluctant to deploy robots with attack capabilities. Control over fire on the ground remains the sole preserve of humans with no technological interface.”[10] However, developments are expected which might radically alter the application of certain provisions, and the provisions of international humanitarian law (IHL) in particular. Taking an interest in the legal aspects to military robotics makes it possible to both understand the legal framework of robot deployment and anticipate potential developments.

Human-Controlled Robots

“Will ground robots and drones one day replace the infantry?”[11] The question deserves to be asked. The issues are, admittedly, first and foremost human and technological, but also legal.

A great deal of speculation surrounds the issue of using robots. “But one of two things results: either humanoid robots acquire autonomy and it is then up to them—not us—to devise their normative systems, or robot autonomy is mere illusion and if there is law to be established then it is very human law concerning use of robots.”[12] Logic of course dictates the second option to be assumed. Robots are today assigned various functions: mine clearance, bomb disposal, reconnaissance and surveillance missions, and in certain circumstances, use of weapons. They are ultimately intended to take part in two types of missions, namely a) support missions and b) combat missions, what is today known as “remote warfare.” However, one thing all robots have in common is that they are remote-controlled.[13] Consequently, the presence of a “person in the loop” makes it possible to apply the usual liability systems with appropriate adaptation for a particular case in point. Operators are responsible for the consequences of robotic devices’ activities in the same way that any member of the military must answer for his or her actions or inactions. They receive orders, take decisions for which they must account, and receive, depending on the context, the legal protection and various degrees of exemption from criminal liability that are stipulated for the military.[14] However, “the day when a robot alone, depending on how it has been programmed, will take the decision to kill a man is really not far away.”[165]Meanwhile, and depending on the political and military decisions that will guide the choice of technology and standards, the effects of using conventional robot technologies need to be evaluated with reference to existing legal frameworks.

An Appropriate Legal Framework, yet Many Question Marks

It is difficult yet necessary to define what is meant by the term “robot.” The difficulty is a genuine one in the absence of any statutory or commonly-agreed definition and the term may refer to either remotely-operated or autonomous machines. The need for a definition is evident because the applicable legal provisions depend on it. The term robot is first, in those cases attracting our attention, an item of military equipment, an expression which conventionally covers “arms, munitions and implements of war.”[16] Legally, a robot is a movable in the sense of Article 528 of the French Civil Code which stipulates that [official Legifrance translation] “animals and things which can move from one place to another, whether they move by themselves or whether they can only move as the result of an extraneous power, are movables by their nature.”

Loss or Harm Caused by a Robot, but a Human Liability

Whatever the scenario, the deployment of robot systems is based today on human decision-making power. As a result, issues arise related to the attribution of harm which may involve national or international legal provisions while at the same time account must be taken of the operational context, the rules of engagement, both global and local, together with the chain of command and, in some case, the device designer's liability. The deployment of robot technologies consequently demands that the liabilities of the various parties are clearly defined—the state, the parties in the chain of command (including political authorities) as well as the manufacturer. The notion of liability refers here to the obligation on natural and legal persons to make good any loss or damage caused by their activities. It is not exclusive, as in parallel to incurring civil or administrative liability; criminal and disciplinary proceedings may be instituted. Use is made of the assets of the various parties on the basis of their involvement in causing the loss or harm. Accordingly, the state must answer for both the consequences of errors committed by members of the military while performing their duties and the excessive use of force, just as it must account for the use of certain equipment. Protocol I Additional to the Geneva Conventions[17] provides, first, that "in any armed conflict, the right of the Parties to the conflict to choose methods or means of warfare is not unlimited"[18] and, secondly, that in "the study, development, acquisition or adoption of a new weapon, means or method of warfare, a High Contracting Party is under an obligation to determine whether its employment would, in some or all circumstances, be prohibited by this Protocol or by any other rule of international law applicable to the High Contracting Party."[19] Military personnel, meaning remote operators and their hierarchy, must answer for their misconduct and, depending on the charge, may see their criminal liability incurred. Lastly, the delicate question arises of the attribution of liability between the user and other parties involved (the designer, manufacturer, and owner). As the design, programming (in part) and operator training in the use of robot systems are part of the manufacturer's role, how can its share of liability be determined when harm occurs?[20]

Ultimately, the application of conventional legal frameworks, as regards liability, leads to a distinction between the consequences of the deployment of robots with regard to domestic law and international law, and particularly international humanitarian law (IHL), some of the principles of which might be infringed by the deployment of equipment having a certain degree of autonomy. Studying robots' legal status makes it possible to envisage the changes to law or international conventions necessary to take into consideration, where needed, legal models that are appropriate to the missions, consequences and operating conditions of current and future robotic devices.

Deployment of Military Ground Robots—Who is Liable for What?

Military personnel, in carrying out their duties, will be applying domestic legal provisions as well as provisions laid down by international conventions. The applicable legal frameworks are stable, whether entailing the involvement of domestic courts, or the international courts which have experienced a resurgence of interest with the adoption of the Rome Statute and the establishment of the International Criminal Court (ICC).[21]

Domestic Liability

With regard to domestic jurisdictions, the overriding principle is the state's immunity from liability during military operations. Indeed, the French Council of State said, more than forty-five years ago now, during proceedings for damages against the French state, that "the measures taken must be viewed as connected, as a whole, to military operations for which, by their very nature, the state cannot be held liable."[22] The judge in the administrative court consequently rejected the claim for compensation submitted.

More recently, examining a claim for compensation for damages as a result of navigation on the Danube becoming blocked after bombing campaigns conducted in the former Yugoslavia in 1999, the Council of State (France's highest administrative court) reiterated that "the state cannot be held liable for military operations, by their very nature, including on the grounds of unequal treatment (specifically 'unequal discharge of public burdens')."[23]

This position of principle is justified either, classically, by reference to the notion of "act of government" which prohibits a judge from examining a claim[24] or, more frequently, by reference to some liability of the state which from the outset, is viewed as being "neither general nor absolute,"[25] which permits, for reasons of sovereignty in particular, the establishment of the "state's immunity from liability arising from military operations."[26] The claim for compensation was considered by the judge in the administrative court but was dismissed. The deployment of robots during military operations has no bearing on incurring the legal liability of the State, which will be dismissed.

However, the state or its agents may be rendered liable in other circumstances, and in particular in cases of peace-time intervention in a foreign state, or indeed in France. For over twenty years now, external operations have been multiplied with varied missions, such as peacekeeping activities or the enforcement of international law, stabilization missions, or training of national forces. Intervention by armed forces abroad is a decision for the government, but "where the said intervention shall exceed four months, the Government shall submit the extension to Parliament for authorization."[27] In the event of injury or damage in connection with such interventions, claims before national courts are possible. However, agreements exist on the status of forces, which frequently stipulate dispute resolution methods and, in particular, out-of-court settlements.[28] The conventional provisions of public authority fault liability (with intention or negligence), or no-fault liability (strict liability), will apply. In the event of personal fault (committed outside official duties), the personal assets of the agent will be used to form compensation.[29] However, the administrative court adopts a broad interpretation of the notion of fault by public servants while performing their duties (for which they are not personally liable) and it operates independently of the definition in the criminal court.[30] If the claim for compensation from the state fails, the victims, following in so doing the natural inclination of society, may be tempted to shift their proceedings and claims to the criminal courts, thus contributing to what is called "the litigation society."[31] Either the French public prosecutor (public prosecution) or the victim (party claiming damages) alike may instigate criminal proceedings. On principle, there is no collective criminal liability. Accordingly, under Article 121-1 of the French Penal Code, "No one is criminally liable except for his own conduct." This also means that, with certain exceptions, there is no vicarious criminal liability.

While criminal liability requires prior intent, there are also, by way of exceptions, some unintentional offenses.[32] Accordingly, Article 121-3 of the French Penal Code stipulates that "the deliberate endangering of others is a misdemeanour where the law so provides" and it adds that "a misdemeanour also exists, where the law so provides, in cases of recklessness, negligence, or failure to observe an obligation of due care or precaution imposed by any statute or regulation, where it is established that the offender has failed to show normal diligence, taking into consideration where appropriate the nature of his role or functions, of his capacities and powers and of the means then available to him" [official Legifrance translations].[33] Many applications are possible when deploying military equipment, and especially robotic devices. As we can see, military staffs are not immune from criminal prosecution, even in the absence of any intent. However, is the conclusion to be drawn that exposure to criminal risk undermines military operations?

The answer has to be negative, for several reasons. First of all, there is a whole series of justifications or defenses that prevent criminal charges.[34] In a case in point, "it is the illegal nature of the act that is removed."[35] Next, alongside these causes of immunity from liability listed in the French Penal Code, the legislature has stipulated a number of guarantees working in the military's favor. First, Article 16 of France's general military statute (encapsulating its "military covenant") brings limitations to the incurring of liability for unintentional acts,[36] and secondly, Article L. 4123-12 of the French Defense Code[37] stipulates that "criminal liability is not incurred by a member of the military who, while complying with the provisions of international law and as part of a military operation taking place outside of French territory, exercises coercion or uses armed force, or gives the order to do so, when this is necessary for the accomplishment of the mission." Lastly, the military is now covered under existing general law, for offenses committed both within French territory[38] and outside it,[39] but its members continue to benefit from certain special arrangements as regards procedure.[40]

International Liability

Military personnel action must fall within the domestic legal and regulatory framework but is also governed by many provisions of public international law (PIL), which include the requirements of IHL.

This, in the first instance, means the United Nations Charter, which governs the terms of the use of force by stating at the outset, in Article 2, its prohibition as a matter of principle.[41] Any intervention must therefore be limited to peacekeeping operations (Chapter 6). However, the Charter provides for two exceptions: first, states' individual or collective self-defense and second, the possibility of collective action decided upon to deal with a "threat to the peace [sic], breach of the peace or an act of aggression" (Chapter 7). Secondly, IHL will evidently be more directly relevant to the deployment of robotic devices in theaters of operation. IHL, essentially based on the Geneva Conventions and their Additional Protocols, is designed to limit the effects of armed conflict by protecting those who are not participating (civilians) or who are no longer participating (the wounded and prisoners of war) in the fighting. IHL is also designed to limit the resources and methods of warfare. To achieve these various objectives, IHL is based on different principles including the principle of proportionality and the principle of discrimination. These are the different principles that might, in future, be infringed by the use of robots. In fact, when the international legal framework for the use of force is respected and the rules of engagement determined for a given operation, "then the principle of military necessity justifies the deployment of the hardware used including robot systems."[42] What causes concern is both the ability to enforce the principles of IHL when new hardware is deployed (drones, ground robots) and to ensure that ethical and legal considerations prevail and, in particular, the first of Asimov's three laws of robotics, i.e. "A robot may not injure a human being or, through inaction, allow a human being to come to harm."[43] The hypothesis of a violation of IHL principles is not a mere case study. Since 2009, Professor Sharkey has postulated many times over that it is not possible to replace a human's judgment and ability to discern and measure whether the principle of proportionality is satisfied or not.[44] However, technologically, such changes are already reality with the implementation of algorithms enabling the requirements of the principles of discrimination (legal objectives) and of proportionality demanded by IHL to be incorporated in the robot.[45] At this time, both ethical and legal principles are hindering robots' attainment of autonomy and explain the reluctance of ground forces to pursue autonomous robots.[46] What makes great vigilance necessary is, obviously, the use of such hardware in conventional conflicts (although all military personnel receive training in the law of armed conflict)[47] but even more so during asymmetrical conflicts.[48]

Internationally, various jurisdictions operate, notably the International Criminal Court (ICC). France recently ratified the Rome Statute and has adapted its own penal legislation by introducing the "offence of war crimes."[49] The ICC is competent to try individuals for war crimes, but its competence is complementary to domestic criminal jurisdictions, which are intended to rule on establishing the facts of possible offenses committed by military personnel including those on foreign soil.[50] Alongside this permanent international criminal jurisdiction, special-purpose courts may be instituted. Thus the International Criminal Tribunal for the former Yugoslavia (ICTY)[51] and the International Criminal Tribunal for Rwanda (ICTR)[52] were set up. Charges against the French state, during a military operation, brought before an international court, cannot be ruled out; however, as external operations essentially take place under an international mandate (UN, NATO, and EU) with rules of engagement (ROE), the determination of those liable for injury or damage will be more difficult.

An Unclear Legal Framework

Deployment of robot systems does not shift the conventional boundaries of liability law but does raise different issues regarding the position of the remote operator, compliance with the provisions of IHL law and the attribution of liabilities. These are just some of the questions that argue in favor of the need for clarifications as regards both the relevance of the status of robots and the development of a legal framework for intervention by international conventions and domestic law.

The Legal Status of Robots

The legal status of robots is a known factor. It is not a *sui generis* classification, but is derived from a classic categorization in civil law which distinguishes persons, being subjects of law (i.e. holders of rights and obligations), and property, being the subject matter of the law. Robots must be deemed movables by their nature in the sense of Articles 527 and 528 of the French Civil Code.[53] This categorization does not raise any major difficulties and is of a kind to satisfy, at this point, the requirements of the deployment of remotely operated robots. It furthermore brings legal consequences that enable the compensation claims of the victims of robot systems to be met. Thus, the robot, a movable, is placed under the responsibility of its custodian. Consequently, a robot is not a subject of law. A robot has neither civil nor criminal liability. The rules of civil liability apply, and in particular Article 1384 of the French Civil Code whereby "A person is liable not only for the damages he causes by his own act, but also for that which is caused by the acts of persons for whom he is responsible, or by things which are in his custody." The provisions relating to property are therefore applicable to robots: the person liable for the actions of the robot and its harmful consequences, if any, is its custodian, i.e. the user. As military equipment belongs, except in special cases, to the state, military ground robots can cause harm which will be made good, in principle, by applying the provisions of the law of public authority liability.[54]

Nevertheless, some legal commentators have wondered about the opportunity to change the legal status of robots, suggesting that robots acquire legal personality.[55] The suggestion is not new but ignores the common categorizations in civil law and, importantly, the reasons for them.[56] In fact, the French Civil Code has only two legal categories: persons and property. As a result, "the distinction between persons and property gives structure to the whole area [i.e. civil law]: the former are subjects of law, i.e. the independent will by which they act makes them ideally suited to bear rights and obligations, while the latter are nothing other than the subject matter of the former's wishes."[57] The distinction between persons and property stems from the need to allocate rights and obligations. While legal personality confers some traditional rights on holders (especially individual rights), it also imposes constraints on them, and in particular the obligation to make good the harmful consequences of their action or inaction from their own assets. Although, at first sight, the question of granting legal personality to robots may cause surprise, it should not be overlooked that the recognition of legal personality for impersonal groups did not come about without some criticism, because legal personality first and foremost results, for a number of commentators, from a legal fiction, including as regards natural persons. In this way, believes Kelsen, "a natural person is not a human being, but a personified unit of legal norms imposing obligations and legal norms conferring rights on a single individual. It is not a natural reality but a legal construct created by the science of law, an auxiliary concept in the description and formulation of law data."[58] In contrast, some legal commentators, including Hauriou, said that legal personality reflected a social and institutional reality.[59] The two ideas can each complement the other. Thus, "the legal person is a fiction, since it is more or less anthropomorphism; yet it is [also] a reality since conferring personality presupposes that a meaningful collective interest equipped with a means of expression has in fact been observed."[60] Finally, in the light of such debates, the effectiveness of legal institutions and instruments that work towards the taking into account of social reality has to be acknowledged. In a thorough study on "Legal persons in French Law,"[61] Professor Gridel raised the question of the usefulness of conferring personality and responded by assigning it two main purposes, in that first, it delivers efficiency in legal proceedings and secondly it provides a mechanism for arranging financial liability. Indeed, "once legal personality becomes a legal device, it is easy to make a legal person a defendant in civilian, administrative or criminal proceedings." The benefit of legal personality, institutionalizing an activity enabling the consequences of actions for damages to be attributed not to natural persons but to private or public organizations, can be deduced.

Should this institution be transposed onto robots, however? The answer is apparently negative. In fact, the point is not so much to create a subject of law to make a robot system exist legally where natural persons fail to do so (the classic purpose of legal personality) than to confer a status on devices which are already the responsibility of a legal person, the state in this instance, deemed more solvent than any other natural or legal person. The state's assets would be spared from the potential attribution of liability, and the new legal entity thus created would be open to criminal proceedings which the state, by way of an exception, cannot be. The use of remotely controlled devices and, eventually, semi-autonomous devices, must first lead to consideration of the attribution of the harmful consequences of their actions. The aim is definitely not to remove any form of liability from their owner. Furthermore, the choice of such a legal construct brings to mind the theory of 'fictitious legal person' used by the administrative courts to designate and punish public bodies using the French "association" legal form in order to avoid the application of public law. The court decided that the purpose is no more and no less than a rejection of the "administrative instrumentalization of legal personality," which aims in part to exempt the public body from the application of extra-contractual liability.[62]

In recent years, deliberations on a new mechanism have been appearing, namely virtual personality that could be attributed to various entities including, by extension, robots.[63] The Council of State itself, in a 1998 report, considering the question of the protection of personal data and privacy, suggested that thought be given "to the issue of the rights of virtual persons, different perhaps from the rights of real persons."[64] To the number of proposals shown at the end of the report, the Council of State suggested "initiating a study into the notion of the virtual person."

Despite these various avenues, there is no overriding imperative, at this time, to make changes to the legal status of robots. In fact, proponents of the extension of legal personality to automated systems are yielding to an appealing idea, namely the transfer of liability from the owner or user to some other subject of law. In so doing, the question is to establish which system of liability might apply in connection with the activities of military ground robots? Traditional legal mechanisms make it possible to meet the most complex demands of the attribution of liability. It can be seen that what matters is less the legal status of robots than organizing the system of liability applicable, if need be by statute, that is to govern the division of liability for compensation, in the event of proceedings, between various parties that will usually include a public body (the state) and users (soldiers) operating within a chain of command (with a military and political hierarchy).

What Changes are Necessary?

The robot, as military equipment, is both a vehicle and, where appropriate, a weapon. Legally, it is a property with the traditional consequences resulting from this categorization. Analogies with the status of animals, which fall into the same legal category, are strong. Property by nature, animals are covered by both general legislation for categorization purposes, and specific provisions to govern certain aspects of the legal framework applicable to them. Accordingly, Article 1385 of the French Civil Code stipulates that "the owner of an animal, or the person using it, during the period of usage, is liable for the damage the animal has caused, whether the animal was under his custody or had strayed or escaped" [official translation]. In the same way, it now seems desirable that international law and domestic law alike take into consideration all aspects of the emergence of air, ground and sea robots in order to set down appropriate legal provisions. Three sets of factors support this argument.

Firstly, the inclusion of robots in various legislative texts, as regards both civil and military matters, should occur without delay, because robot deployment is a paradigm shift which is only going to accelerate. Indeed, the use of robots is approved not only for many defense applications (combating piracy, reconnaissance missions, intervention in theaters of operations such as the drones deployed in Iraq, Kosovo or Afghanistan) but also in security for border surveillance, emergency aid, public security or even environmental protection.[65] Secondly, robotic devices share the characteristic of being unmanned vehicles. However, various sets of regulations currently block most movement of such devices. Hence, "the addition of either civilian or military drones to air traffic requires that such systems be certified or approved to fly, and that special air traffic rules be set down owing to the difficulties that they raise as regards the risk of collision with other aircraft."[66] The aim is to procure compliance, in particular, with the Chicago convention, Article 8 of which stipulates that "each State undertakes to ensure that the flight of such aircraft without a pilot shall [...] obviate danger to civil aircraft."[67] An information report to the Senate (the French upper house) recommends the adoption of appropriate Europe-wide regulations, stipulating in particular "payment of compensation in the event of incidents."[68] Similar difficulties are encountered for ground robots, as the French Highway Code makes no provision for unmanned vehicle traffic and thus forms an obstacle to the development of robotic devices in France especially during internal security operations. Various proposals have been drawn up, first "using traffic authorization and certification processes of a kind similar to what is done for manned military ground vehicles"[69] and, secondly, looking further ahead, "it is conceivable that one day, implementation of all the subtleties of automatic compliance with the highway code within a robot will be achieved."[70] Second, in the United States, some states have started work on bringing about consistency in their various regulations as regards both flight clearance for UAVs[71] or unmanned vehicle traffic on the roads.[72]

Third and last, while robots can be categorized as vehicles with all the legal barriers that entails, they can also in some circumstances be considered weapons. As such they are subject to different domestic and international provisions addressing that aspect. Armed robots are already a reality with drones able to conduct bombing missions (there are many examples, from Kosovo in 1999 to Libya in 2011). Irrespective of the theater of operations, the harm caused, particularly to the civilian population, can be of great magnitude.

Beyond the principle of the state's immunity from liability during military operations, the key question arises of the liability framework to apply to the use of robotic devices, especially on domestic territory in peacetime, given the deployment of such equipment on foreign soil has to be governed, in part, by international conventions along with the international organization under the aegis of which the operations in question are conducted.[73] The issue is naturally of interest not only to the Ministry of Defense but also to other public and private operators. And it is a complex issue. In fact, military ground robots have dual legal categorization. They are firstly land motor vehicles to which are applied the provisions and procedures resulting from this categorization. But they are secondly military equipment able to fulfil various functions beyond a transport purpose, which then becomes incidental. For the first categorization, there is legislation which confers jurisdiction on judicial courts "to rule on any action for damages seeking compensation for loss or harm of any kind caused by any vehicle."[74] However, the objective of the law is more to unify litigation surrounding vehicle accidents, in favor of the judicial courts, than it is to organize a liability system.

For the second categorization, several factors argue in favor of a liability framework suited to the special case of military ground robots with, if need be, some aspects shared with other types of device. First of all, it should be pointed out that "compensation for loss or harm caused by the armed forces is an outdated principle in comparison to the general theory of the state's immunity from liability which has prevailed for a long time."[75] The actions of military personnel have thus contributed, through various administrative court rulings, to the building of frameworks governing fault liability (for intention or negligence) and no-fault liability (strict liability). As a consequence, taking an interest in the armed forces' changing methods of intervention and their effects relates to a continuing wish to see victims compensated; it follows that it is important, in the face of a certain reluctance in response to the introduction of new technologies, to bring some legal certainty to their use by organizing a legislative system of reparation for loss. It means, lastly, as regards operators acting within a hierarchy, the accompanying decline in individual liability in favor of socialization of risk. This development is evidenced by the establishment of mechanisms replacing civil liability, such as insurance, or, as regards administrative law, the extension to the scope covered by the notion of fault by public servants while performing their duties and also the development of legislative and case-law no-fault liability frameworks based, in particular, on risk.

Under the influence of first legal commentators[76] and then the judicial courts,[77] the restrictive reading of liability for loss or harm caused by objects in one's care introduced by paragraph 1 of Article 1384 of the French Civil Code came to be replaced by a general principle of no-fault liability for such loss or harm, this being understood to be a strict liability based on the risk attached to "liability for care or custody of the object and not for the object itself."[78] Various specific legislative provisions were introduced, either from the outset such as Article 1385 for loss or harm caused by a kept animal, or subsequently. This is the case, for example, with the French law of 5 July 1985,[79] which establishes special provisions for compensating victims of road traffic accidents, or the law of 19 May 1998 which transposes into national law the EEC Directive of 25 July 1985 on liability for defective products.[80]

However, it should be noted, following Professor Truchet that "no-fault (administrative) liability is viewed as an invention of administrative case law,[81] which the legislators and judicial courts appropriated subsequently."[82] No-fault liability founded on risk has been extended a great deal, especially in cases of the "occurrence of risk events involving staff or third parties."[83]

The demand from some quarters for the development of liability for loss or harm caused by objects in one's care testifies to the desire to deliver a solution to an unusual and sometimes complex situation.[84] In fact, "the fact that loss or harm has been caused not by military personnel directly, but by a robot has a dual impact: first as regards the causal link between the offense, its consequences and its perpetrator, this link being undermined by the introduction of the robot intermediary which complicates the judge's task; and second as regards the intention of military personnel, which is found to be difficult to prove as far as semi-autonomous devices are concerned."[85] The search for a suitable liability framework must not ignore the responsibility of the operator, nor disregard security imperatives. For both of these reasons, and to meet a fair division of the burden, fault liability (with intention or negligence) should remain the benchmark reparation system even though it is useful to consider the establishment of a no-fault liability framework for a hazardous activity, i.e. the deployment of robotic devices.[86]

One avenue remains to be explored, which is the state taking out insurance as a result of the deployment of robots, in the military sphere naturally, but also in various security functions. Contrary to a widespread idea, the principle by virtue of which "the state is its own insurer" is merely standard practice, motivated by financial considerations since a decision taken by the French Finance Minister on 23 September 1889.[87] It means that, with a few exceptions, the French state does not take out civil liability insurance and, furthermore, many statutes draw their own conclusions as a result.[88] However, public bodies are free to take out insurance and should, in making the decision, undertake a conventional cost-benefit analysis of doing so, to compare the risk of loss or harm arising and the concomitant compensation with the cost of insurance.

Lastly, "if lives and money are saved, with a genuine improvement in the effectiveness of missions undertaken, then driverless vehicles will become an essential tool in conducting warfare."[89]

Notes

1. Christian Malis, Didier Danet, and Hew Strachan, *La guerre irrégulière* (Irregular Warfare), Economica, 2011; Didier Danet and Christian Malis, *Frères d'armes? Soldats d'Etat et soldats privés* (Brothers in Arms? State Soldiers and Private Soldiers), Economica, 2011.

2. Ronan Doaré and Henri Hude (eds.), *Les robots au cœur du champ de bataille* (Robots at the Heart of the Battlefield), (Economica, 2011).

3. Défense et Sécurité nationale, Le Livre Blanc (Defense and National Security White Paper), La Documentation française (pub. by the French Stationery Office, 2008), 208.

4. Dominique Luzeaux and Delphine Dufourd-Moretti, "L'autonomie ajustable en robotique militaire terrestre" ("Adjustable Autonomy in Military Ground Robots"), *La Jaune et la Rouge,* May 2010 (No. 655), 30.

5. Christian Malis, "La robotisation de l'espace de bataille nous promet-elle une nouvelle révolution dans les affaires militaires ?" ("Does Robotization of the Battlefield Promise a New Revolution in Military Matters?"), *Défense et Sécurité Internationale,* (No. 10) January 2010, 21 et seq.

6. Maryse Bergé-Lavigne and Philippe Nogrix, Information report to the Senate (French Upper House) on behalf of the Committee on Foreign Affairs, Defense and the Armed Forces, following an assignment on the role on drones in the armed forces, Senate reports, 2006, No. 215.

7. V. Altran, "Réflexions juridiques sur les conflits opposant les robots et les soldats" ("Discussions on the Legal Options Regarding Conflicts Between Robots and Soldiers"), *Les cahiers du CHEAr,* September 2004.

8. Louis Gautier, *La politique de défense de la France après la guerre froide* (France's Defense Policy after the Cold War), PUF, 2009, 275 et seq.

9. For some, "The introduction of robots within the armed forces must be combined with some monitoring of the legal aspects which would alter the rules of respect and dignity for civilians." V. Altran, "Réflexions juridiques sur les conflits opposant les robots et les soldats."

10. Francois Cornut-Gentille, Opinion submitted on behalf of the French Committee on National Defense and the Armed Forces, regarding the draft budget for 2012, filed with the office of the President of the National Assembly (France's Lower House) on 25 October 2011, No. 3775, 169.

11. Cornut-Gentille, Opinion submitted on behalf of the French Committee on National Defense and the Armed Forces, 169.

12. Dominique Lecourt, "Le droit des robots" (Robots and the law), *La Croix,* 18 September 2007.

13. However, certain functions, such as movement, may be partly autonomous or semi-autonomous, even if an operator is able to take control.

14. Articles L.4123-10 to L.4123-12 of the French Defense Code.

15. Joseph Henrotin, "Quelques élémentaires de la robotique militaire terrestre" ("The Rudiments of Military Ground Robots"), *Défense et Sécurité International* (No. 10) January 2010, 8.

16. Articles L. 2331-1 and L. 2333-1 of the French Defense Code. French government order of 17 June 2009 setting the list of military and similar equipment subject to a special export procedure, JO [France's Official Gazette] 20 June 2009, p. 10087.

17. Protocol Additional to the Geneva Conventions of 12 August 1949 relating to the Protection of Victims of International Armed Conflicts (Protocol 1).

18. Article 35 of Protocol I.

19. Article 36 of Protocol I.

20. “Training course contents are currently determined by the manufacturers that build the drones.” See R. Jaulmes, “Aspects réglementaires pour la robotique aéroterrestre” (“Regulatory Aspects of Air-Ground Robots”), in Ronan Doaré and Henri Hude (eds.), *Les robots au cœur du champ de bataille,* 134.

21. Law No. 2010-930 of 9 August 2010 Adapting French Criminal Law to the Establishment of the International Criminal Court, JO [France’s Official Gazette] 10 August 2010, 14678.

22. CE (Council of State) 30 March 1966 Société Ignazio Messina et Cie, Application. No. 59 664.

23. CE (Council of State) 23 July 2010, Sociétés Touax and Touax Rom, Application. 328757. See H. Belrhali-Bernard, “L’îlot de l’irresponsabilité de l’Etat du fait des opérations militaires” (“The State’s Immunity from Liability Arising from Military Operations”), case note filed under CE (Council of State) 23 July 2010 Sociétés Touax et Touax , AJDA 2010, P. 2269; H. Flavier, “L’absence de responsabilité de l’Etat du fait des opérations militaires” (“The Absence of State liability Arising from Military Operations”), Dr. Adm. 2010, No. 10, comm. No. 136.

24. See Louis Gautier, “La politique de défense de la France après la guerre froide,” 276.

25. TC (Tribunal des Conflits – jurisdictions court) 8 February 1873, Blanco, Rec. 1st supplement, p. 61, concl. David.

26. See H. Belrhali-Bernard, “L’îlot de l’irresponsabilité de l’Etat du fait des opérations militaries.”

27. Article 35 of the Constitution of 4 October 1958 (from the Constitutional Law No. 2008-724 of 23 July 2008 on the modernization of the institutions of the Fifth Republic, JO [France’s official gazette], 24 July 2008, p. 11890).

28. As defined in a Status of Forces Agreement (SOFA), for example; out-of-court settlement is described and encouraged by the internal texts: see French Government Order of 23 December 2009 setting out the competencies of the armed forces’ administrative offices as regards compensation for loss or harm caused or sustained by the French Ministry of Defense, defending the Ministry in the administrative courts and legal protection for military and civilian staff, French official gazette, JO [France’s official gazette], 30 December 2009, text no. 41.

29. TC (Tribunal des Conflits—jurisdictions court) 30 July 1873 Pelletier, Rec. 1st supplement, 17.

30. TC (Tribunal des Conflits—jurisdictions court) 14 January 1935, Thépaz; see Jean Rivero and Jean Waline, Droit administratif (Administrative Law), Dalloz, 2000, No. 288.

31. See “La judiciarisation des conflits” (“Increasing Litigiousness in Conflict Resolution”), Inflexions No. 15, La Documentation française (pub. by the French Stationery Office), 2010.

32. Article 121-3 [of the French Penal Code] “There is No Felony or Misdemeanour in the Absence of an Intent to Commit It” (para. 1).

33. See Article L.4423-11 of the French Defense Code.

34. Jean Pradel, Droit pénal general (General Criminal Law), 18th edition, Cujas, No. 306 et seq.

35. Jean Pradel, Droit pénal general (General Criminal Law), 18th edition, Cujas, No. 307.

36. “Subject to the provisions of paragraph 4 of Article 121-3 of the [French] Penal Code, military personnel can only be found guilty on the grounds of paragraph 3 of the same Article for unintentional acts committed in fulfilling their duties if it is established that they have failed to show normal diligence taking into consideration their capabilities, powers and means available to them together with the specific difficulties of the mission entrusted to them” (Law no. 2005-270 of 24 March 2005 Concerning the General Military Statute, JO [France’s official gazette], 26 March 2005, 5098).

37. Wording from Article 17 of French Law no. 2005-270 of 24 March 2005.

38. Article 1 of French Law no. 82-621 of 21 July 1982 on investigation and judgement of offences as regards the military and state security amending the French Codes of Criminal Procedure and Military Justice, JO [France's Official Gazette] 23 July 1982, 2318.

39. Article 32 of French Law no. 2011-1862 of 13 December 2011 on the distribution of litigation cases (between competent courts) and the streamlining of certain court procedures, JO [France's Official Gazette], 14 December 2011, 21105.

40. See Articles L.698-1 and L.698-2 of the French Penal Code.

41. Article 2 states "The use of force is prohibited."

42. DGA (Directorate General for Armaments), Opérations extérieures et robotique, Un éclairage juridique sur l'emploi des robots en OPEX (External Operations and Robotics, Legal Clarification on the Operational use of Robots), ONERA (French Ccenter for Aerospace Research), 16 October 2007.

43. See Isaac Asimov, *I, Robot*, Gnome Press, 1950.

44. Noel Sharkey, Professor of Artificial Intelligence at the University of Sheffield. Noel Sharkey, "Death Strikes from the Sky: The Calculus of Proportionality," IEEE Science and Society, Spring 2009, 16.

45. Kenneth Anderson and Matthew Waxman, "Law and Ethics for Robots Soldiers" *Policy Review,* No. 176 1 December 2012.

46. Francois Cornut-Gentille, Opinion submitted on behalf of the French Committee on National Defense and the Armed Forces, op. cit. p. 169.

47. "All military personnel must be trained in the knowledge of and compliance with the rules of international law applicable in armed conflicts" (Article D.4122-11 of the French Defense Code).

48. Kenneth Anderson and Matthew Waxman, "Law and Ethics for Robots Soldiers."

49. Article 1 of the Rome Statute. See Doreid Becheraoui, "L'exercice des compétences de la Cour pénale internationale" ("The Exercising of the Competency of the International Criminal Court"), Revue internationale de droit pénal (International Review of Criminal Law), 2005, 3, vol. 76, 341.

50. Defense agreements, cooperation agreements, and SOFAs frequently stipulate a division of jurisdiction between France and the host country.

51. UN Security Council Resolutions 808 of 22 February1993 and 827 of 25 May 1993.

52. UN Security Council Resolution 955 of 8 November 1994.

53. Articles 527 and 528 both state "Property is movable by its nature or by prescription of law."

54. See Didier Truchet, Droit administratif (Administrative Law), PUF, 2011, 383 et seq.

55. P. W. Singer, "Ethical Implications of Military Robotics," The 2009 William C. Stutt Ethics Lecture, US Naval Academy, 2009. http://www.usna.edu/Ethics/_files/documents/PWSinger.pdf. Accessed 11 October 2013; Peter M. Asaro, "Robots and Responsibility from a Legal Perspective" in Proceedings of the IEEE 2007 International Conference on Robotics and Automation (ICRA'07).

Rome, April 2007.

56. For a summary of the key points in the debate, see Didier Danet "Enjeux généraux et problématiques juridiques" ("General Issues and Legal Problems") in Ronan Doaré and Henri Hude (eds.), *Les robots au cœur du champ de bataille,* 11 et seq.

57. R. Libchaber, "Perspectives sur la situation juridique de l'animal" ("Viewpoints on the Legal Position of Animals"), *Revue trimestrielle de droit civil* (Quarterly Review of Civil Law), 2001, 1, 293 et seq.

58. Hans Kelsen, *Pure Theory of Law,* trans. C. Eisenmann, (Dalloz, 1962), 225.

59. Maurice Hauriou, *Principes de droit public* (Principles of Public Law), 2d edition, Dalloz, 2010, 98.

60. Jean-Pierre Gridel, “La personne morale en droit français” (“Legal persons in French Law”) *Revue internationale de droit comparé* (International review of comparative law), Vol. 42 (No. 2) 1990, 496.

61. Jean-Pierre Gridel, “La personne morale en droit français,” 495 et seq.; Leon Michoud, *La théorie de la personnalité morale et son application au droit français* (The Theory of Legal Personality and its Application in French Law), 1909, (reprint LGDJ, 1998).

62. Francois Paguet and Clemence Paillet, *La théorie des associations transparentes, réflexions sur la personnalité morale fictive* (The Theory of Transparent Association:; Thoughts on Fictitious Legal Personality), Conference for the René Cassin Class, Legal personality, 30 May 2007.

63. Daniele Bourcier, “De l’intelligence artificielle à la personne virtuelle : émergence d’une entité juridique ?” (“From Artificial Intelligence to the Virtual Person—Is a Legal Entity Emerging?”), *Droit et Société* (Law and Society), No. 49, 2001, 847; Didier Danet, “Enjeux généraux et problématiques juridiques.”

64. Council of State, “Internet et les réseaux numériques” (“The Internet and Digital Networks”), Paris, La Documentation française (pub. by the French stationery office), 1998.

65. For an overview of civilian and military applications, see: Michel Asencio, Philippe Gros, Jean-Jacques Patry, “Les drones tactiques à voilure tournante dans engagements contemporains” (“Tactical rotary wing drones in contemporary military action”), *Fondation pour la recherche stratégique* (Foundation for Strategic Research), October 2010.

66. Maryse Bergé-Lavigne, Philippe Nogrix, Information report to the Senate (French upper house), 2006.

67. Convention on International Civil Aviation, 7 December 1944.

68. M. Bergé-Lavigne, P. Nogrix, Information report to the Senate (French upper house), 2006; see Eric Pomès, “Comparatif drones et robots militaires terrestres en droit international” (“Comparison of drones and military ground robots in international law”), in Ronan Doaré and Henri Hude (eds.), *Les robots au cœur du champ de bataille,* 187.

69. R. Jaulmes, “Aspects réglementaires pour la robotique aéroterrestre,” 135.

70. R. Jaulmes, “Aspects réglementaires pour la robotique aéroterrestre,” 135.

71. See Stew Magnuson, “Regulatory, Technological Hurdles Stand In Way of Domestic Drone Mandate” *National Defense* May 2012, http://www.nationaldefensemagazine.org/archive/2012/May/Pages/Regulatory,TechnologicalHurdlesStandInWayofDomesticDroneMandate.aspx(accessed 11 October 2013).

72. Daniel R. Rosen, “Driverless Cars & The End of Distracted Driving” 14 February 2012 http://www.danielrrosen.com/2012/02/driverless-cars/. Accessed 11 October 2013.

73. CE (Council of State) 30 March 1966 Société Ignazio Messina et Cie.

74. French Law no. 57-1424 conferring jurisdiction on the judicial courts to rule on any action for damages taken against a public body and seeking compensation for loss or harm of any kind caused by any vehicle, JO [France’s official gazette], 5 January 1958, 196.

75. J. Moreau, Jcl Adm , fascicule 894, Responsabilité de l’armée (The armed forces’ liability), No. 1.

76. Raymond Saleilles, *Les accidents du travail et la responsabilité civile* (Workplace accidents and civil liability), 1897; Louis Josserand, De la responsabilité du fait des choses inanimées (On liability for harm caused by inanimate objects), thesis, Paris, 1897; L. Josserand, “Le travail de refoulement de la responsabilité du fait des choses inanimées” (“Work on curbing liability for harm caused by inanimate objects”), D. 1930, chron. 5.

77. Cass. , civ. (Court of Cassation [French Supreme Court of Review], Civil chamber), 16 June 1896 Teffaine, DP 1897, 1, p. 433, Saleilles case notes; Cass. Ch. Réunies, (Court of Cassation [French Supreme Court of Review], Plenary session) 13 February 1930 Jand’heur, D. 1930, 1, 57.

78. Cass. Ch. Réunies, (Court of Cassation [French Supreme Court of Review], Plenary session) 13 February 1930 Jand'heur.

79. French Law No. 85-677 of 5 July 1985 to improve the situation of victims of road traffic accidents and accelerate compensation procedures, JO [France's official gazette] 6 July 1985, 7584.

80. Articles L.1386-1 to L.1386-18 of the French Civil Code.

81. See CE (Council of State) 21 June 1985, Cames, GAJA (Major rulings of administrative case law) No. 6.

82. Didier Truchet, Droit administrative, 415.

83. Didier Truchet, Droit administrative 421.

84. V. Altran, "Réflexions juridiques sur les conflits opposant les robots et les soldats."

85. V. Altran, "Réflexions juridiques sur les conflits opposant les robots et les soldats."

86. See Jean-Sebastien. Borghetti, "La responsabilité du fait des choses/ou du fait des activités dangereuses" ("Liability for loss or harm caused by objects or hazardous activities"). grerca.univ-rennes1.fr/digitalAssets/268/268671_jsborghetti.pdf. Accessed 11 October 2013

87. This decision "is purely a financial opportunity and is viewed as an internal guideline which the state may ignore when it deems it necessary" (F.-P. Franc Valluet, De la règle "l'Etat est son propre assureur" (On the rule that "the state is its own insurer"), RCAT 1978, 596).

88. See Article L. 211-1 of the French Insurance Code.

89. Michel Asencio, Philippe Gros, Jean-Jacques Patry, "Les drones tactiques à voilure tournante dans engagements contemporains," 35.

Chapter 8
A Comparison of Drones and Military Unmanned Ground Vehicles (UGVs) in International Law
by Eric Pomes

"Surgical warfare" is the term used by the Obama administration to justify the use of drones in the war against terrorism.[1] This decision inevitably raises concerns for internationalists, given that such a doctrine recommends the use of force—which all international law attempts to rule out of international relations. It is not sufficient to note this behavior; it must be properly apprehended in order to establish the conditions under which it is permissible and the consequences arising from any breach of these conditions.

Such an undertaking is all the more important given the ever-increasing number of UAVs and UGVs on the battlefield—in 2008, there were over 12,000 in Iraq—and the ever-increasing number of States with this kind of technology, indeed there are around forty, plus a certain number of Non-State armed groups.

As in the case of new players in armed conflicts, lawyers are confronted with new issues with regard to UGVs and UAVs. Lieutenant Colonel Philippe Frin has dealt with the consequences of their use in the light of international humanitarian law; I will take a broader approach and attempt to determine under which body of law these new combat resources can be apprehended, in the light of international law.

This question is not merely a theoretical one; it is of particular interest because the law may be taken either as a weapon or as a limiting factor. The law can be deemed to be used as a "weapon" if it is used to achieve military objectives. Americans use the term "lawfare" to designate this strategy, which may be defined as a strategy of use or misuse of the law as a substitute for conventional military resources in order to achieve an operational objective or prevent the enemy from achieving its objective. This weapon may be used to support or criticize an operation; its objective is to gain the moral high ground over an enemy in public opinion.[2] In this perspective, better understanding of the applicable rules will enable optimum use of these new combat resources.

A Variable Body of Law

Determining which law applies to UAVs and UGVs involves defining them in legal terms and studying their mission.

A Different Legal Definition

Before moving on to a more in-depth analysis, UAVs and UGVS need to be legally defined in order to allocate them to existing legal regimes; these will then govern their use.

The fact that they are unmanned—a term which is closer to the actual state of affairs than the descriptor 'pilotless'—is not of major significance when it comes to establishing this definition. This characteristic does not have any real consequence on their legal qualification. What is important, however, is the environment in which they are used—land, sea, or air.

Viewed thus, defining what drones are appears to be a complex issue. Some argue that the absence of a pilot means they are missiles. However, this definition is not satisfactory because a missile is an unmanned, pilotless, autonomous vehicle which cannot be recalled, whether it is guided or non-guided, and which carries a weapon or any other useful payload. Even though drones share a number of these characteristics, they cannot legally be considered as missiles in that they are designed to be used more than once and thus to return to their point of departure.[3] Pursuant to Annex 7 to the 1944 Chicago Convention[4] and article L. 6100-1 of the French Transport Code,[5] if drones are capable of taking off and travelling in the air, they should be qualified as aircraft; more specifically so in application of article 3 (b) of the Chicago Convention, as State aircraft.[6]

The rules of aerial warfare and some aspects of the law of the air therefore apply to drones. But only some aspects, since by virtue of article 3 (a), the Chicago Convention does not apply to State aircraft. The Chicago Convention, however, requires States to take the safety of civil aircraft into consideration when using unmanned aircraft.[7]

With respect to UGVs, based on their primary feature which is the ability to move on the ground by means of a motor enabling them to travel, and following analogous reasoning to that for UAVs, UGVs may therefore be compared to and defined as land-based motor vehicles. It follows that the rules of ground warfare and the rules relating to land vehicles apply to them.

Another difference between these two types of robots is that contrary to UGVs, UAVs are subject to a particular control regime—the missile technology control regime (MTCR). This control is the result of a 1987 agreement whose purpose was to put an end to the proliferation of ballistic and cruise missiles and unmanned aerial vehicles (drones). To achieve this, for exports, States have engaged in the control of certain technologies to ensure that equipment and technology is not diverted to develop carriers capable of carrying a first-generation nuclear payload. This difference in qualification must therefore be taken into account when writing their doctrine of use and operational Rules of Engagement (ROE).

In order to have a more accurate idea of the legal regime applicable to robots, a second distinction must be drawn. This does not relate to the type of robot but to the use of such unmanned combat vehicles.

Distinction in Terms of Missions

The distinction is not drawn between drones and robots but rather on the basis of the missions assigned to them.[8] The first type of mission that comes to mind is that of offensive missions whose aim is to eliminate the enemy's human and material resources. Without doubt, the best example of this is the use of drones to apply the policy of targeted killings. In this instance, drones are used to eliminate an individual who is deemed to be dangerous and outside national territory. In addition to these missions, which garner extensive media coverage, robots can be used for missions that can be qualified as passive, in that they do not involve making a strike against the enemy. The variety of these missions demonstrates the versatility and therefore the soldiers' interest in robots. Robots enable them to carry out intelligence and mine clearance missions. For example, *Predator* drones are used by the United States for surveillance of the border with Mexico.

This distinction as to their use also affects how legal liability is defined. Indeed, the applicable legal regime can be determined according to their missions. The rules applicable to each of these combat vehicles can be envisaged within each of these regimes, according to the nature of the vehicle in question.

Since they do not feature in any treaty, their use is not prohibited by international law.[9] In the light of laws armed conflict law, the lawfulness of the use of robots as a means of combat could however be called into question if their use were to cause superfluous damage or fail to distinguish between combatants and civilians.[10] It should be noted that the use of drones by the United States in its war on terror results in a great number of civilian losses. These losses may be explained in a number of ways. The first is the obvious proximity of civilians to "combatants." The second is related directly to their conditions of use and the appraisal of their legality in the light of armed conflict law. The use of drones leads to a distance being established between the battlefield—and thus the enemy—and the personnel operating them. Additionally, it is not always possible to have a clear appraisal of the situation on the ground. Whereas article 50 of Additional Protocol I to the 1977 Geneva Convention requires States to refrain from the use of force against a person if there is a doubt as to their civilian or non-civilian status, this distancing could lead to a certain degree of moral permissiveness, i.e. an uncontrolled increase in force, in that it reduces the risks to the personnel operating them.[11] However, since States do not take this position, their use must be apprehended in terms of responsibility; the issue becomes one of deciding whether the use of robots is in breach of the rules of international law.[12]

Use of Unmanned Combat Vehicles and Prohibition of the Use of Force

The use of these combat vehicles raises the question of compatibility with article 2 (4) of the UN Charter prohibiting the use of armed force in international relations. It also raises the question of whether the use of robots and drones automatically constitutes prohibited use of armed force on a State's territory.

In the event of breach of international law, two types of responsibility may be envisaged. The first is the individual responsibility of the robot or drone operator—the possibility of the robot or drone making autonomous decisions is not envisaged here—or that of the person giving the orders. This qualifies as criminal liability, the grounds for which will vary from war crimes to unintentional misdemeanors.

The second type of responsibility is the international liability of the State for illegal acts. International liability can be analyzed in terms of sanctioning illegal acts, meaning breach of international law, for which a State can be held responsible. Article 1 of the draft article relating to the responsibility of States says that "any illegal international act engages the responsibility of the State responsible for it."[13] The responsibility of the State is thus engaged if the State breaches any of its agreed or usual obligations; for instance, respecting another State's sovereign airspace. Similarly, article 5 (2) of resolution 3314 specifies that crimes of aggression engage the State's international responsibility.

Standard Policing Measures

Article 2 (4) prohibits all uses of armed force including targeted military operations. However, in actual fact, not all operations in which armed force is used are prohibited by this article.[14] In this respect, there is a threshold condition, below which these operations are qualified as policing measures—limited-scale coercion—and these are not covered by article 2 (4). Only operations which cross this threshold constitute prohibited use of armed force. This question of thresholds will be analyzed in practice. An operation is a policing measure if it is targeted, limited, does not lead to conflict between State forces, and targets individuals rather than the State. For example, Pakistan did not claim that the American missiles—which can be taken as analogous to drones in this instance—fired over its territory in 1998 constituted a breach of article 2 (4). Similarly, reconnaissance operations carried out by drones or robots could be qualified as policing measures.

Any military operation on a State's territory without its consent does however undermine its sovereignty and is therefore liable to engage the international liability of the State responsible for it. Seen thus, a drone overflight of a State constitutes a breach of the State's sovereignty by virtue of article 1 of the Chicago Convention, which specifies that there should be no airborne activity without the knowledge of the State being over flown. Article 3 (c) of the Chicago Convention specifies that "No State aircraft of a contracting State shall fly over the territory of another State or land thereon without authorization by special agreement or otherwise, and in accordance with the terms thereof." This prohibition is expressly reiterated in article 8 with respect to unmanned aircraft.[15] Reconnaissance flights have also been recognized as violations of the airspace of the State being over flown by the International Court of Justice, in its judgment of 27 June 1986 "Military and paramilitary Activities in and against Nicaragua."[16]

Today, however, the practice of the United States reveals that drones and robots are used in situations other than those which are covered in legal terms by the regime for armed conflict; this is the case for the war against terror. Their use is covered by *law enforcement* rather than armed conflict law.

The use of force against one or more individuals by means of robots must therefore abide by common law applicable to delinquents. There is no rule in international law allowing a State to pursue, still less kill, an individual it deems to be a criminal by violating the sovereignty of another State. This kind of action engages the liability of the State responsible. The use of robots in such circumstances is only legal under international law if there are grounds for this use due to circumstances that would render such an act legal. These circumstances constitute a temporary cause of exoneration, whose effect is to provisionally suspend the execution or requirement of conformity of behavior with an international obligation of the State. Consequently, the existence of such circumstances makes behavior which in other circumstances would be in breach of an international legal obligation. A distinction must be drawn between situations in which there is no illegal act, due to objective circumstances, independent of the State's behavior, such as force majeure circumstances, distress or necessity, and on the other hand, scenarios in which a deliberate, proven act would no longer be illegal, in response to another illegal act committed by the State responsible for the original act; such acts might include self-defense, countermeasures and the consent of the adversely affected State.[17]

Given the extraordinary nature of such circumstances, the Americans have sought other legal grounds to justify the use of drones. For instance, US Forces that start to monitor the movements of Taliban deem that they can continue to do so into Pakistan.

As grounds for crossing the Pakistani border, they invoke the right of pursuit. The ROE applicable in Afghanistan in 2007 therefore included the right of pursuit in the case of continuous, uninterrupted pursuit of the Taliban.[18] These grounds are drawn from the law of the sea. Indeed, coastal States have the right to continue the pursuit of a foreign vessel into international waters if the pursuit began in the State's territorial waters.[19] Article 111 of the United Nations Convention on the Law of the Sea, signed on 10 December 1982 in Montego Bay, authorizes hot pursuit when "the competent authorities of the coastal State have good reason to believe that the ship has violated the laws and regulations of that State." This immediately gives rise to a first comment: the use of such a legal basis is not admissible when a drone or robot is pursuing a target beyond a land border rather than at sea. If the pursuit is taking place at the sea, paragraph 5 of article 111 allows for pursuit to be exercised only by "warships or military aircraft, or other ships or aircraft clearly marked and identifiable as being on government service and authorized to that effect." Pursuit on the seas by a drone therefore appears to be possible. Paragraph 6 of article 111 does however lay down conditions: the aircraft must give the order to stop. Pursuit is thus authorized only if the drone can communicate with the ship being pursued. This condition is all the more important in that "it does not suffice to justify an arrest outside the territorial sea that the ship was merely sighted by the aircraft as an offender or suspected offender, if it was not both ordered to stop and pursued by the aircraft itself or other aircraft or ships which continue the pursuit without interruption."

In any case, the use of robots must abide by human rights. This means that the use of force will be possible only in the case of absolute necessity and that it must be proportionate.[20] This obligation relates both to relationships between States and individuals and relationships between individuals and State officers conducting operations.

This is why the "targeted killing" policy, i.e. the use of lethal force by a State against a particular individual representing a threat and who is not under the control of that State, with the intention of killing them by means of a drone, is problematic. The use of drones is however an integral part of American strategy for neutralizing Al-Qaeda terrorists, regardless of which country they reside in. The execution by means of this process of a number of Al-Qaeda members by the Central Intelligence Agency in Yemen in 2002 is a good example of this.[21] The legality of such action is dubious under human rights law.

Consequently, such a practice may be qualified as an extra-judicial execution, consisting of arbitrarily depriving an individual of their life in the absence of any independent competent court ruling with no appeal possible.[22] Such a practice is characterized by the arbitrary nature of the designation of the individual and the possibility of mistaken identity. This designation takes place without any legal process, which is the only competent route for a State of law to decide on the guilt of an individual. It is therefore clear that it is at odds with the right to life and fair trial. The existence of other means of putting an end to the illegal activities of the individual designated is an additional issue weighing in the balance against the legality of the action.[23] Except in exceptional circumstances, imminent threat or an absence of other means, this kind of practice appears to be illegal in positive international law.[24] The State's responsibility and that of its officers may be engaged.

A Violation of Article 2 (4)

The State's international responsibility may also be engaged for violating the prohibition on the use of armed force if the act is serious and directed against the State, i.e. with the aim of compelling the State to adopt a specific behavior. The use made of robots is more important than the nature of the robots themselves. When it has serious consequences or is intended to compel the State to comply, it may be qualified as an aggression as defined by articles 1 and 3 of General Assembly Resolution 3314 of 14 December 1974. Article 1 states that "aggression is the use of armed force by a State against the sovereignty, territorial integrity or political independence of another State, or in any other manner inconsistent with the Charter of the United Nations."[25] Similarly, if an act is not directed against the State, violation of Article 2 (4) can be established if the State knows that its operation will cause substantial damage. Article 3 (b) specifies for example that "bombardment by the armed forces of a State against the territory of another State or the use of any weapons by a State against the territory of another State" may be qualified as an act of aggression.

Even if the use of robots were to correspond to these circumstances, it would be lawful if it were carried out in application of permission by the Security Council or in self-defense. For this to be the case, a State would have to have been the victim of armed aggression by another State. Consequently, even if this may be debatable, the use of these means to respond to an attack by Non-State actors is not lawful in positive international law as stated by the ICJ in its order *"Armed Activities in the Territory of Congo"* dated 19 December 2005, unless the intervention is requested or authorized by the territorial State and provided it remains within the limits set by this authorization.[26] It follows that while, for instance, the use of a drone to eliminate a Taliban member in Afghanistan does not pose a problem if IHL is adhered to, this use is more problematic in Pakistan if it takes place with no regard to the arguments providing grounds for the use of force.

The existence of these prohibitions does not mean that the use of force has disappeared in international relations. It should be specified that international humanitarian law applies whether the use of force is lawful or unlawful. In both international armed conflict and non-international armed conflict, the use of force must adhere to the relevant rules of armed conflict law, in particular the principles of discrimination and proportionality.[27] The principle of discrimination obliges protagonists to distinguish between combatants and civilians. The principle of proportionality obliges them to refrain from launching an attack which can be expected to cause collateral loss of human life in the civilian population, injury to civilians, damage to civilian property, or a combination of such loss and damage which would be excessive compared to the direct, tangible military advantage expected.[28] The application of this principle involves the issue of the suitability of the resources used with regard to the desired military effect. This is because it attempts to reconcile "opposing values, such as the interest of the protagonist in conducting the military operation and the interest of civilians who are not taking part in hostilities but could be victims of this action."[29]

A cursory mention should be made of one of the most extensively discussed issues today in international humanitarian law—direct participation in hostilities. This relates not to the status of the drone or robot's victim but to that of their user, if the latter is a civilian contractor or a civilian member of the intelligence services. In the context of armed conflict, both have been qualified by the ICRC as civilians participating directly in hostilities.[30] Consequently, unlike combatants who benefit from criminal immunity for their actions provided these abide by armed conflict law, these civilians may be held criminally liable for their acts.

Uncertainty as to the International Responsibility of States

In both scenarios envisaged, the difficulties reside in demonstrating that the conditions for the State's responsibility to be engaged are met in the actual circumstances. The requesting State must demonstrate the existence of a causal link between the damage and the illicit act. Demonstrating this is not very difficult. For example, in the case of an extra-judicial execution, the link between moral damage (an attack on honor) and the illegal act (a violation of sovereignty) is not difficult to demonstrate. However, demonstrating that this illegal act is the responsibility of a State is more problematic. In the previous example, while there is no difficulty in proving the existence of the damage (the bombardment) it would still be necessary to demonstrate the involvement of a drone or robot in committing the act at fault. Above all, it will be necessary to establish its nationality. Similarly, a demonstration of the violation of a State's sovereignty by a robot or drone on the occasion of a reconnaissance mission raises obvious difficulties as far as proof is concerned, unless the device is photographed, intercepted or in the hands of the authorities of the State in which the operations took place.

If these conditions are met, Article 30 of the draft resolution on the State's international responsibility requires the State to cease its unlawful behavior and provide assurance and guarantees that the behavior will not be repeated. Article 31 obliges the State to make full restitution for all harm, which includes both material and moral damage caused by the unlawful act.

Furthermore, in such a scenario, the victims, understood as "persons who, individually or collectively, have suffered harm [...] through acts or omissions constituting serious violations of international human rights law or gross violations of international humanitarian law have the right to remedy and reparation."[31] Such rights are envisaged in a General Assembly Resolution dated 16 December 2005 entitled "Basic principles and guidelines on the right to a remedy and reparation for victims of gross violations of international human rights law and serious violations of international humanitarian law."[32] However the legal scope of this resolution, like any provision of declarative law, is uncertain. According to para. 4 of this resolution, States have the duty to investigate and, if there is sufficient evidence, the duty to bring to prosecution the person allegedly responsible for the violations and, if found guilty, the duty to punish them. Moreover, the victims have the right to "adequate, effective and prompt reparation for harm suffered."[33] Failing this, at least for French soldiers, legal action brought before the ICC—which acts in the event of a legal vacuum—would still be a possibility.

Conclusion.

While it may be felt that for armed forces these new combat resources are indispensable in new conflicts, they should be used with caution with regard to international law, especially if this use goes against the tide, i.e. the major shift in contemporary international law in favor of jus contra bellum.

The International Committee for Robot Arms Control, which met in September 2010, is of the opinion that these combat resources constitute a threat to international peace and security and a threat for civilians during armed conflict, and that they run the risk of potentially undermining international law, in particular human rights. These risks should lead to them being apprehended by an arms control regime.[34]

Notes

1. Renaud Girard, "Les guerres "au scalpel" d'Obama contre al-Qaida" ("Obama's 'surgical warfare' against al-Qaeda"), *Le Figaro,* 16 August 2010.

2. C. J. Dunlap, "Lawfare Today: A Perspective", *Yale Journal of International Affairs,* Winter 2008, 146-154. Also Eric Pomes, "Les implications juridiques de la contre-insurrection. Vers une convergence de la nécessité militaire et de la protection des non-combattants?" ("Legal implications of counter-insurgency. Towards convergence of military necessity and protection of non-combatants?"), *Stratégique,* 2012, No. 100-101, 305-337.

3. A/57/229, La question des missiles sous tous ses aspects (Examining every aspect of the issue of missiles), July 23, 2002.

4. Any machine that can derive support in the atmosphere from the reactions of the air other than the reactions of the air against the earth's surface.

5. Any vehicle capable of taking off and moving in the air shall be defined as an aircraft in application of this code.

6. Aircraft used in the military, customs, and police departments are deemed to be State aircraft.

7. Article 3 (d) "The contracting States undertake, when issuing regulations for their state aircraft, that they will have due regard for the safety of navigation of civil aircraft."

8. Lieutenant Colonel Marcus Fielding, "Robotics in Future Land Warfare", *Australian Army Journal,* 2006, Vol. III, No. 2. 99-108.

9. Armin Krishnan, *Killer Robots: Legality and Ethicality of Autonomous Weapons,* (Burlington, 2009), 89.

10. Noel Sharkey, "Grounds for Discrimination: Autonomous Robot Weapons", *RUSI Defence Systems,* October 2008, 86-89.

11. P.W. Singer, "Military Robots and the Laws of War," *The New Atlantis,* Winter 2009, pp. 27-47.

12. Mary Ellen O'Connell, "The International Law of Drones" *ASIL Insights*, 12 November 2010, vol. 14, No. 36.

13. Appended to A/RES/56/83, 28 January 2002.

14. Olivier Corten, "Le droit contre la guerre. L'interdiction du recours à la force en droit international contemporain" ("Law versus warfare: Prohibition of the use of force in contemporary international law"), (Paris, 2008), 65 et seq.

15. Article 8—*Unmanned aircraft* No aircraft capable of being flown without a pilot shall be flown without a pilot over the territory of a contracting State without special authorization by that State and in accordance with the terms of such authorization. Each contracting State undertakes to ensure that the flight of such aircraft without a pilot in regions open to civil aircraft shall be so controlled as to obviate danger to civil aircraft.

16. "Activités militaires et paramilitaires au Nicaragua et contre celui-ci (Nicaragua c. États-Unis)" ("Case concerning the military and paramilitary activities in and against Nicaragua (Nicaragua v. United States of America)", fond arrêt du 27 juin 1986 (Judgment of 27 June 1986), 14 para. 91.

17. Veronique Huet, "Les circonstances excluant l'illicéité et le recours à la force" ("Circumstances ruling out unlawfulness and the use of force"), *Journal du droit international,* 2008, no. 1, 75-99.

18. "Hot pursuit of Al Qaeda and Taliban terrorist command and control targets from Afghanistan into Pakistan so long as pursuit is continuous and uninterrupted" or if "the head of US Central Command or the secretary of defense allow such incursion" or to "recover personnel that may have been taken across the border."

19. Philippe Vincent, *Droit de la mer* (The law of the sea), (Brussels, 2008),136-137.

20. ECHR, *Ergi vs. Turkey,* judgment, Reports 1998-IV, Petition no. 23818/94, 28 July 1998, para. 79.

21. On 3 November 2002, six men were killed in their vehicle, which was struck by a missile launched from a Predator drone controlled by the United States. This strike was deemed to be an extra-judicial execution. See E/CN.4/2003/3, 13 January 2003, para. 39.

22. Francoise Bouchet-Saulnier, *Dictionnaire pratique du droit humanitaire (A practical dictionary of humanitarian law),* 2nd Edition, (Paris, La découverte, 2000).

23. Such a policy therefore appears to be in violation of the right to a fair trial and the right to life. The right to life may be waived in certain circumstances. See ECHR, Grand Chamber, *McCann and others v. the United Kingdom,* judgement of 27 September 1995, Petition no. 18984/91, series A no. 324, pp. 45-46. The judgement states that "Against this background, in determining whether the force used was compatible with Article 2 (art. 2), the Court must carefully scrutinise, as noted above, not only whether the force used by the soldiers was strictly proportionate to the aim of protecting persons against unlawful violence but also whether the anti-terrorist operation was planned and controlled by the authorities so as to minimise, to the greatest extent possible, recourse to lethal force." (para. 194) and that "The question arises, however, whether the anti-terrorist operation as a whole was controlled and organized in a manner which respected the requirements of Article 2 (art. 2) and whether the information and instructions given to the soldiers who, in effect, rendered inevitable the use of lethal force, took adequately into consideration the right to life of the three suspects." (para. 201).

24. Philip Alston, *Report of the Special Rapporteur on extrajudicial, summary or arbitrary executions: Study on targeted killings,* A/HRC/14/24/Add.6, May 28, 2010, p. 5, para. 10.

25. Aggression implies the specific desire of a State to attack another State. See *Oil rigs,* judgement, *ICJ 2003 Reports,* para. 64.

26. *Armed activities in the territory of Congo (Democratic Republic of Congo v. Uganda),* judgement, ICJ 2005 Reports, 168.

27. John J. Klein, "The Problematic Nexus: Where Unmanned Combat Air Vehicles and the Law of Armed Conflict Meet," *Air & Space Power Journal,* July 2003; Chris Jenks, "Law from above: unmanned aerial systems, use of force, and the law of armed conflict" *North Dakota Law Review,* 2009, 649-671.

28. Article 57 2) a) iii) of Protocol I; K. Watkin, "Targeting: Pragmatism and the Real World", *Canada Army Journal,* Summer 2005, vol. 8.2, 75-84.

29. Enzo Cannizzaro, "Contextualizing proportionality: *jus ad bellum* and *jus in bello* in the Lebanese war,*" International Review of the Red Cross,* 2006, vol. 88 (no. 864), 275-290.

30. Nils Melzer, *Interpretive Guidance on the Notion of Direct Participation in Hostilities under International Humanitarian Law,* ICRC, June 2009. http://www.icrc.org/Web/eng/siteeng0.nsf/htmlall/direct-participation-report_res/$File/direct-participation-guidance-2009-icrc.pdf. (accessed 15 October 2013).

31. A/RES/60/147 para. 8.

32. A/RES/60/147; Pierre d'Argent, "Le droit de la responsabilité internationale complété? Examen des Principes fondamentaux et directives concernant le droit à un recours et à réparation des victimes de violations flagrantes du droit international des droits de l'homme et de violations graves du droit international humanitaire" ("Additions to law on international responsibility? An examination of the fundamental Principles and directives concerning the right to recourse and reparation by the victims of flagrant violations of human rights law and serious violations of international humanitarian law"), *Annuaire français de droit international* 2005, vol. 51, 27-55.

33. A/RES/60/147 para. 11.

34. The purpose of such a regime is to limit arms in various respects (for example their quantity, scope and lethal capacity).

Chapter 9
Robots and Civil Liberties
by Thierry Daups

Introduction

Civil Liberties and Robots in a Rationally Ordered Society

Isaac Asimov, the famous American author of the Three Laws of Robotics, might have appreciated dealing with a topic like this. The issue is one of assessing the effects of the use of robots on civil liberties. The difficulty here lies in the ability to understand the issue, given the recent emergence of military and civil robots. We must therefore make our assessment in advance, starting from existing law and procedures in adjacent fields, such as IT.[1] As a consequence, measuring the impact of robots on civil liberties requires us first to define the latter, especially in their relationship with technology; then we shall observe that this assessment is part of a triangular relationship. Finally, we shall determine the issues involved in this topic.

Social Order Between Civil Liberties and Technology-Based Security

To do this, we shall start from the hypothesis that this assessment relates to the establishment of a society based on the search for optimal individual and collective security, by adapting the system of individual and collective civil liberties to the level of security that the powers that be wish to introduce.[2] The military or civil robot, combined with other resources, participates in this objective and in an increasingly rational management of human society that respects civil liberties.[3] The latter arise from a subtle political arbitration, relayed by law, between the general interest of society and the citizens' demand for individual freedom. This gives rise to various administrative arrangements, which determine public order.[4]

However, today, the political desire to increase the security of citizens is leading to a legal modification of the conditions for applying liberties, in order to increase security, especially via increased surveillance of the population.[5] This development translates a philosophical inversion[6] where, instead of the presumed goodness and innocence of the human being,[7] it is suggested that the principle of precaution be applied to him or her, due to the potential danger that this human being represents. This approach authorizes *a priori* intervention, in advance of the commission of an offence, against individuals who have yet to commit any punishable act.[8] This requires every individual human being to be:

1. Identifiable,
2. Traceable,
3. Dissuadable, and
4. Punishable.

The use of technology by the State and its specialist services is gradually achieving this result.[9] Reduced to a set of personal information, the individual is made virtual and transparent. This machinization of society and security could lead to a mechanical application of the law by reducing the occasions when a human judge intervenes in favor of a “mathematical” application of the ideal legal order invented by the legislator. Thus, more than the technology itself, it is the use of technology by a public authority that presents a threat to civil liberties.[10]

Now, the assessment of the robot’s impact on civil liberties will be based on the conception of the connection between the robot, the soldier or policeman, and the person or the target.

What are the Consequences of the Triangular Relationship: Robot, Soldier, and Person?

The introduction of the robot upsets the classic duo: soldier—target (object, armed or unarmed civilian, young/old, friend/foe or unknown), to create a triangular relationship that causes us to ask the following questions, before looking at its components.

First of all, should the weapon adapt to man or vice versa; what level of artificial intelligence will be the most appropriate to ensure a good relationship between man and robot for the execution of a mission?[11] We will also take into consideration the difference in operating logic and, therefore, in the nature of the soldier and the robot. The first is the result of experience, professional training, individual philosophy, and personality. The second obeys its own determined logic. What will be the influence of this difference in nature on the decisions to be taken? Add in the design of the robot and therefore its degree of autonomy; the nature of the mission to complete and its legal and political framework, and finally the reaction of people in front of the robot, or in front of the robot—soldier partnership. These elements allow us to appreciate the roles of each member of the triangle.

The soldier first, acting on the authority of his superior officers, is carrying out a mission in a particular legal framework. Responsible for the use of the robot, he takes the decision whether or not to use it. What relationship protocol should be established between them?

Next, the robot is carrying out a mission and takes a certain number of decisions in its course. Without responsibility, it reacts in accordance with its mission in response to the action of a third person and in relation to the soldier. Its level of autonomy determines its capacity to make a decision.

Finally, the people, who might have varying statuses—child, adult, armed or not armed, acting peacefully or aggressively, friend or foe—how should the robot consider them? As a precaution, should the instruction be that every person is a potential enemy to be destroyed or is it necessary to wait until the person’s behavior betrays a malevolent intention to trigger a decision and an action by the robot or the soldier?

It follows from this relationship that decision and responsibility are key to the use of robots.

Let us turn first to the issue of the decision. The robot’s mission and nature will allow us to assess its ability to make its own decision, without human intervention or with the soldier. Will such a decision have a legal value and an opposability equivalent to one taken by a human being? The answer would depend on the assessment of the legal framework of the action and on the share of the decision taken, or not, by the soldier, alone or with his superior officers, and would seem to be yes in the light of existing procedures.[12] Equally, we shall insist on the difference in nature between the decisions: the policeman, via a human appreciation of the seriousness of the offense will decide to report it to trigger the sanction, while the robot will have no other choice than to make this report, in accordance with the mathematical conditions that it gathers and with its programming (embedded software, parameters). This difference in nature would call into question civil liberties; hence the importance of the procedures in this area that ensure that the liberties are respected. Thus the overly confident recourse, without a spirit of doubt, to the expertise of the computer or of a robot, which will encourage a person to make a decision that he would not have made had he verified this expertise, would present a danger.[13]

The issue of responsibility ensues from that of the decision. Its assessment will rely on a scale of autonomy and responsibility. The more the robot is autonomous, the less will man be responsible. However, as the robot cannot be responsible, a human being or an institution must be. More precisely, how can the level of human responsibility be determined in relation to a robot's level of autonomous decision-making? Finally, in the case of the fully autonomous robot, will the master still be liable for the fact when an unsuitable decision causes harm to a third party[14] or a malfunction causes harm?[15] Here too, procedures will play a key role.

The relationship between robotics and civil liberties determines a more general set of issues.

The Robot and the Conditions of its Use in Compliance with Civil Liberties

In brief, the robot remains above all an instrument in the service of a specific mission conducted in a multiform framework.[16] Consequently, current law is already adapted to the technical constraints and provides a certain number of answers to the questions posed by the use of robots; but not all answers are available, due to the specific nature of these machines.[17] There ensues a neutrality of the robot in respect of civil liberties, due to the materiality of its action, avoiding direct confrontation with these liberties. Alone, its use for essentially security ends, in the framework of a democratic state or otherwise, by the competent authorities or actual people, would be in doubt.[18] Up to what point will it be necessary to adapt the human being to the robot? As a consequence, the assessment of the robot's impact on civil liberties would be measured against the changes that it causes in its legal environment.

We will thus see how robots encounter civil liberties, plus the procedural and technical guarantees that would be required in their use to provide maximum guarantees for civil liberties while ensuring the security of the person and of society.

The Influence of the Definition of Robots in Their Encounter With Civil Liberties

An assessment of the encounter between robots and civil liberties requires us to define them and determine the legal frameworks of their encounter.

Material and Legal Definition of the Robot

The Material Definition

The thing should be simple though. In fact, imaginings of the robot in animal or humanoid form would influence a realistic definition. Thus the robot may be described by its level of mobility, of autonomy and therefore of artificial intelligence, but also by its shape and its material or immaterial nature, when we are talking about computer software that IT people refer to as "bots" and which operate continuously, without human intervention, making their own decisions. Thus the robot is able to analyze a real situation, associate a solution with it and, as a consequence, take a decision or leave a decision up to a human authority. It is a degree of intermediation between man and his action, according to the philosophers.

However, are mobility and materiality two essential characteristics of the robot?[19] PP30, indeed, defines the robot as a mobile, pilot-less, reusable machine.[20] Is mobility an indispensable characteristic though, given the computer software mentioned above? Would its artificial intelligence capabilities be the main characteristic of the robot? Would the material or immaterial form, its mobility or immobility, not come into play as the extension of its said capacities to carry out its mission?[21] And one must not forget to discuss the robot's multi-purpose or specialist nature.[22]

South Korea's law on the development and promotion of the distribution of robots would confirm this impression.[23] It defines the robot in article 2-1: "The intelligent robot is an autonomous machine that understands its external environment independently, that operates and reacts alone." Article 2-2 of the same law states that the design and operation of the robot are subject to a robot ethical charter. Finally, the objective of a robot, according to the South Korean legislature is to contribute to the quality of life of the citizen and to the development of the economy.[24]

Let us note here merely that the robot is essentially defined by its artificial intelligence, used to analyze its environment, adapt to it and, finally, to take a decision, independently. The most extensive possible autonomy seems to be the characteristic of the robot. The ability to decide and, therefore, its nature and the legal significance of its nature therefore occupies a central place.

Thus, the robot, carries out an essentially physical task following an order. And this could be done under remote control, semi-autonomously or autonomously. In the latter case, its artificial intelligence for carrying out its physical task adapts to its natural and artificial environment and, to this end, takes a certain number of decisions required to complete its mission, without human intervention.

It remains to measure the robot's impact on civil liberties to determine its legal nature.

The Legal Definition: a Movable, a Vehicle, and a Weapon

Today, the robot does not constitute a legal entity identified as such in law. We shall note its absence from the *Manuel de droit des conflits armés (Legal Handbook for Armed Conflicts)* and even from international arms conventions.[25] For the moment, we can only proceed to its legal description, first of all in civil law.

If the robot belongs to an actual person or to a civil or military corporate entity,[26] it is indeed a movable according to the definition in the civil code,[27] as it can be transported or it can move itself. However it could acquire the character of an immovable by destination, according to Article 524 of the civil code. Thus a robot belonging to the army could be an immovable by destination if it were allocated to a mission carried out within the confines of a military site or barracks and never beyond these boundaries.[28] However, a robot intended to carry out missions outside the barracks or military site would indeed be a movable. This being so, is this movable a vehicle?

The highway code defines categories of vehicles and equipment for travelling on the public highway.[29] Ever since law 54-1424 of 31 December 1957 brought liability cases related to vehicles under the jurisdiction of judicial tribunals, whether or not they are the property of a public entity, any machine capable of moving by its own means, be it an engine or any other means (animal, wind, oars, pedal arrangement), is deemed to be a vehicle. It follows that the technical characteristics of its movement determine if it is a vehicle or not. Thus, a drone, a fully robotic military craft ought to be considered as a vehicle. Finally, a robot which only carries out missions to locate, monitor, and neutralize an enemy, on a public or private highway or on the land, would constitute a vehicle because of the automotive capability that allows it to carry out a mission.[30]

Finally, as for the qualification of the robot as a weapon, according to the current national legislation, two complementary approaches authorize this.

The legislation on weapons subject to export permits, on the basis of the technical characteristics and the description of their main characteristics, a legal definition of a drone and a robot.[31] The drone is legally an unmanned aerial vehicle[32] and, according to the decree of 17 June 2009, the robot[33] is a “Handling mechanism which can be of two types, continuous trajectory or point by point, which may use sensors and which displays all of the following characteristics:

1. Has multiple functions;
2. Capable of positioning or arranging materials, parts, tools or special devices by variable movements in a three dimensional space;
3. Comprising three or more closed or open loop controls, which may include stepping motors, and
4. Fitted with a programming capability accessible to the user by the learning method or by a computer which may be a logical programming unit, in other words without mechanical intervention.[34]

Finally, the robot used as a robotic platform on which a weapon is installed would fall into the second category of controlled war materiel, weapons and munitions:[35] the materiel destined to bear or to use firearms in combat.[36]

In conclusion, the military robot appears most often legally as a movable, belonging to a public entity. It may be covered by the law related to category two weapons of war and subject to export licences, or may constitute the weapon itself. However, does it constitute a new weapon?

The Robot, an Intelligent Weapon Subject to International Law

That said, the robot is, by its nature, a new weapon. Its special features distinguish it from the traditional weapon, manually separated from the human being, requiring a human action to operate it (a dagger, a rifle, a battle tank, a ship, an aircraft, a mine, etc.). Here, on the contrary, the amalgamation of decision-maker and object makes the robot more dangerous as its level of autonomy increases, due to the operation of its purely rational logic. If, however, in the future, there is a rapprochement of the soldier's and the robot's ability to take autonomous decisions in the framework of a predetermined mission, we hope that the human being will distinguish himself by his ability to introduce something which cannot be set as a parameter: an appreciation, an evaluation that allows him to take a decision other than the one he would usually have taken and the one that the robot would have taken. In so doing, the robot, as an auxiliary to the soldier and undertaking an operation that involves another target individual (an enemy to be put out of action, to be monitored, or a person to be searched), finds itself interacting with the latter. This is not without influence on the assessment of the robot in relation to civil liberties, in addition to the fact of it being a weapon.

It remains to identify its legality in respect of international disarmament law. Actually, is the robot an authorized or a banned weapon? The robot does not appear in the glossary of traditional weapons, and the treaty on conventional forces in Europe appears not to offer any clarification.[37] Nor do the conventions on inhumane weapons or the ban or restriction on the use of some traditional weapons that could be deemed to produce excessive traumatic effects or as striking indiscriminately mention robots.[38] However, as a consequence, the robot would have to comply with these international requirements to constitute an internationally legal weapon. Finally, the robot, would have to be able to distinguish between a combatant and a civilian, between a military target and civilian property, and even be able to identify a cultural asset protected by international law.[39] All are abilities to discriminate, which require intelligence and specific programming capable of interfering with the decision to unleash a destructive round.

We would classify robots in accordance with their design and their mission, by distinguishing robots that constitute the weapon itself from those destined to carry a weapon. Thus, the robot that was merely the vector for a prohibited weapon would be authorized, unlike the robot that constitutes that weapon. This distinction, however, does not necessarily correspond to the reality, insofar as the robot might combine the two functions: both gathering information and containing an explosive. It would not however constitute an insidious weapon. Finally, we will add that the robot should not be used to commit war crimes, genocide or crimes against humanity or to attack fundamental freedoms.

To close, we shall note the existence of a legal study indicating three legal circumstances where the State would be implicated by a robot.[40] In the first place, it would be a case of the engagement of the State's civil liability under international law (the country where the operation occurs) and under internal law (French law). In the second place, criminal liability under international law and under internal law would also be involved. In the last place the liability of the soldiers would come into play as operators or as commanding officers. Now, in what circumstances would the military robot encounter civil liberties?

Procedural Frameworks Where Robots and Civil Liberties Meet

From Temporary States of Security to Permanent Security

While the battlefield is the usual field of action for military robots, their intervention outside of this area as a force for public order is still possible. It is in this context that Army robots would encounter civil liberties in three legal situations, where the application of the liberties changes gradually from exercise without restriction to restriction.

The first usual situation is where these liberties are exercised in the framework of their application procedures. The citizen will be able to exercise their rights and the administrative judge will exercise control over the acts of the administration applying them.[41] At this stage, the use of military robots by soldiers has, *a priori,* no basis. However, civil robots may still be used by civil or military police forces in a civil setting.[42] It is merely a case of ensuring respect for public order in a normal situation.

The second, relating to legally specified exceptional circumstances, arising from major disruption to public order, organizes a legislative and regulatory reduction in the application of these liberties. The judge, with less control, assesses the legality of the measures taken by the powers that be. It is in these circumstances that the military robot would encounter civil liberties and where the law of armed conflicts[43] distinguishes between international conflicts and non-international armed conflicts, such as civil wars (which will not be discussed here). The latter category is itself separated from "situations of internal tension, internal disturbances, rebellions and other similar cases of violence which are not considered to be conflicts as such."[44] Thus, situations where public order is disturbed form a circumstance where the military would use robots in a civil context. The *Code de la défense nationale (National Defense Code)*[45] governs those situations where the military forces contribute to the maintenance of public order; these are: a state of siege,[46] in the service of defense,[47] standby,[48] mobilization,[49] maneuvers and exercises,[50] jurisprudence rules for exceptional circumstances and, finally, a state of emergency.[51]

The third situation finally, corresponds to a normal situation with exceptional procedures. For if the preceding legal frameworks are not applicable, the permanence of the threat, in essence a terrorist threat on the national territory or to French interests abroad, requires the continuity of special measures, such as the so-called VIGIPIRATE plan.[52] This institutes a permanent state of surveillance and control of the population; and this is outside the exceptional situations described above.

The Influence on Civil Liberties

Do these various legal arrangements reduce civil liberties? The use of military robots on these occasions would encounter civil liberties, such as, for example, the following:

1. The right to property: overflight, intrusion, voluntary/involuntary, legal/illegal.
2. The right to move freely: monitoring of movements, speed checks, parking, etc.
3. The right of assembly; to protest: unexpected gathering, entry to a meeting place, number of protestors, identity of the protestors; this raises the question of the existence or otherwise of a right to anonymity.
4. Image rights.
5. Privacy (knowledge of the identity of persons met, of private or public places visited, etc.).

6. The right to work: the robot replaces a person, but most often it is to perform an activity hazardous to humans.
7. The ban on discrimination: racist stereotyping when carrying out identity checks.
8. The demarcation of virtual areas and borders.

In this, it is not the robot as such that will forbid movement, close a theater, or arrest a person. However, these technical actions offer the forces of order additional capacities in the execution of their mission. It operates as the instrument of the application of the military or civil forces' police jurisdiction. However, the encounter between robots and civil liberties will have particular characteristics.

We shall consider first the usefulness of using military robots in operations to maintain public order. Are they adapted to such missions whose aims are not identical to those of a purely military conflict? While we might suppose that military robots designed for reconnaissance, observation, materials handling or transport or even for defensive actions would pose no special difficulties, would it not be otherwise for robots fulfilling an offensive function?[53] Would they be able to kill or not to kill? Is a demonstrator an enemy? The use of military robots outside the battlefield would imply flexibility in their autonomy, their artificial intelligence and their technical capacities for carrying out a mission of a civil nature in a precise legal framework.[54]

This circumstance would require a distinction to be made between the battlefield and the public order environment. The latter would tend to amalgamate a public place[55] (highway, a facility open to the public, a public service) and a private place where illegal acts requiring investigation are occurring.[56] We can easily imagine robots used for this purpose.

In addition, we shall consider the effect of the robot's form and size on civil liberties. Must it, in fact, be identifiable as a robot, or can it be disguised, as far as the citizen is concerned, to carry out its mission? We will suppose that the robot must be identified as such[57] to dissuade the commission of offenses and that in other circumstances, such as information gathering, its identification would be made impossible.[58] Finally, we will not forget that the robot's form has an influence on its acceptance by the individuals affected by its action.[59]

Finally, the last character consists of the robot's ability to intrude due to its capabilities: size, storage of sounds and images, decision to act, authorizing identification, location, discretion, or even connection to one or more computer networks. Normal in a military conflict, the use of these intrusive capabilities in the civil setting would remain questionable because they confront civil liberties, even when these are limited as the result of a state of emergency or siege.[60] To what extent do these physical and virtual technical resources constitute disproportionate behavior?

At the end of the day, the robot in its relationship with civil liberties participates as a complement to other tools in the establishment of an impalpable, increasingly virtual, chain surrounding the individual in the pursuit of his personal activities, even those which cause no disturbance to public order.

We can understand then the central importance of legal procedures to apply civil liberties and to determine the legal conditions for the intervention of robots.

The Implication of and Legal Guarantees on the Use of Robots

For a specialist like Colonel Thomas Adams, part of the difficulty with military robots arises from the fact that they would make the use of force easier as well as make going to war easier and difficult to control due to the creation of a complex environment that man will not always be able to master.[61] Thus it is important to set standards for the triangular relationship mentioned in the introduction and envisage procedures and guarantees on their design to protect civil liberties.

The Legal Implications of the Use of Robots for Civil Liberties

At What Procedural Stage and For What Physical Task Would the Robot be Introduced?

To reconcile the robot's effectiveness and respect for civil liberties to prevent the latter being adapted, to their detriment, to the technical constraint, we need to determine the best stage for the intervention of the robot in a legal procedure. A few examples will demonstrate this.

First, let us consider vehicle speed checking by automatic radar units. It fulfils[62] the desire to automate[63] the procedure as completely as possible, starting with the detection of the offense and ending with the payment of the fine and also provides a system which discourages[64] recourse to a judge to contest the offense. Thus, the policy design of speed checks conditioned the design of the legal procedure and the technology used, which also feeds back into the procedure. It follows that the digital photo is admissible unless evidence to the contrary is provided,[65] and that CACIR[66] is the theoretical scene at which the infraction is committed for the whole of France. Finally, the dispute relating to the offense goes to the representative of the public ministry, who examines its admissibility while defending the public interest.[67] From this process, it transpires that the automatic recording of the infraction occurs at a precise moment in the procedure, which is amended to guarantee its full effectiveness.

Equally, the design of identity cards and biometric passports is responding to technical and security constraints. The desire to make them impossible to reproduce is leading to worldwide and European harmonization thanks to technology: the use of a standard photo taken by a competent agent on an approved device and the introduction of personal biometric data. Do the latter not infringe the human being's intrinsic privacy? Here too we shall determine the stage at which it would be useful to use a technology-based process that the security concerns would justify.

Finally, governments, including Japan's, are considering the introduction on the public highway of robot policemen whose presence raises the following questions. Will it be necessary to make any individual immediately identifiable by comparing his face with various databases? Or will this presence make it compulsory to carry a digital identity card that could be checked remotely via an RFID chip? Or allow the robot to analyze facial expressions to reveal a person's intentions; authorize it to force a person to reveal its identity? Will it also be necessary to publicize the fact that a street, neighborhood or town is under robot surveillance and finally, will the robot have to be identifiable by the citizen or will it be unmarked? These questions also raise the issue of the stage in the procedure at which the robot intervenes, its ability to take decisions and therefore its competence. Consequently, if the robot itself does not infringe on civil liberties, it does however participate in a procedural system established for this purpose which could do so.

Thus the use of the robot would occur at a particular and predetermined stage in the procedure to guarantee that its use was compliant, not only with its capabilities but also with a particular mission. In this way, its use will be part of a process where the international rules on the use of weapons or on respect for property and persons who are not military targets would be observed. It would be necessary to establish the particular conditions for its use: what is the best stage in the procedure for using it to respect the liberties? Who decides on the action to be taken: the soldier, the superior officer, the robot, all three? What technical and legal training will the soldier who uses the robot require? What type of mission may the robot carry out and does its use comply with the prescriptions?

At the end of the day, how valuable will the use of a military robot be in operations to maintain public order? The legal impact of the decision taken then by the robot therefore occupies a central place.

The Legal Status of the Robot's Decision

Like digital photos from roadside radar, the legal effect of decisions taken by robots would be assessed against two categories of decisions considered in respect of their objective and of their legal consequences. We should make a distinction between the purely technical decisions, i.e. those related to the mere workings of the robot, and those related to its legally approved action which result either in allowing or denying an action to the soldier or finally in limiting the rights of a third person.

Thus the first of the robot's decisions would have no legal effect as they are linked to its internal workings. The situation would change as soon as they caused damage to a person or to property. For decisions relating to the robot's action in the framework of a specific procedure: the assessment of their legal nature would result either from the law that recognized their legal value (the radar photo, for example) or from their legal effect on the exercise of a civil liberty, a fundamental right or an international legal ruling. Would the best guarantee not be provided by procedures, especially ones to ensure the robot's neutrality?

Technical and Procedural Guarantees to Ensure the Robot Respects Civil Liberties

In the face of the robot's intrusive capabilities, the guarantee of civil liberties would require the recognition of the citizens' right of access to the technical standards and data stored by the robot. Equally, will it be necessary to load the essential standards that must be observed into the robot's artificial intelligence?

Guaranteeing Civil Liberties by Access to the Technical Standards and to Information Stored by the Robot

Public law already provides the citizen with the right of access to documents and other types of information. We will consider the creation of the *Commission d'accès aux documents administratifs* (Committee for Access to Government Documents), or even the *Commission nationale informatique et liberté* (France's data protection authority) which, in particular, guarantees citizens access to any of their personal data collected by a computerized process. The essential issue resides, however, in the status of these bodies as independent governing bodies. In this capacity, they have the jurisdiction and powers needed for their task. Thus, a similar right and a similar body would need to be created in the area of robotics due to the special nature of this new field (a robotics regulatory body, for example).

At this stage, we shall identify a citizen's right of access in case of a robot malfunction, whether or not the person suffers direct harm. The technical standards used to ensure its mechanical, electronic and software operation, and without forgetting all of the sensors and other devices not directly supplied by the manufacturer, would be accessible in conditions yet to be specified to preserve their confidentiality. Such a right would play an essential role in determining the respective liabilities. This right would be distinct from the right to access yet to be defined to all of the data relating to a person or a group of people gathered by a robot on operations. Finally, access to the protocols on the use of the robot would be necessary. These concern the conditions for its introduction in the field as defined by the manufacturer and those defined by the Army for the execution of the mission.

However, due to its nature, the classification of the information gathered by the robot would form an obstacle. We shall suppose that the citizen will have access to all data concerning the robot's design if he is the victim of damage caused by a malfunction of the robot to allow evidence of the wrong done to be established. However the information obtained in the course of a military mission or a mission to maintain public order would be harder to access. A purely military mission would justify a special procedure for accessing the information, as is already the case with the *Commission consultative nationale du secret de la défense nationale.*[68] A mission to maintain public order carried out by a robot would authorize easier access as the information thus collected would be administrative or computer documents.

How is this information gathered? The first method would be the installation of a "black box" recording all of the robot's actions, both to ensure its operation and to complete its mission, without forgetting the instructions received. These data would be stored for an appropriate period in the "black box" and on an external medium for a different length of time.

Finally, the creation of a governing authority independent of political, economic, administrative, and military influence is needed. On this point, we will observe that, in France, EU law had to separate telecommunication manufacturers from the service providers, especially to distribute telephone apparatus. This was to avoid a conflict of interest and protect competition. Such a principle could be applied here. If we could imagine the existence of a useful link between the military administration and the robot manufacturer responsible for meeting military requirements, it would be essential for the institution responsible for guaranteeing compliance with the relevant standards to be wholly independent. This independence would not put at risk civil liberties, national security, or industrial secrets. On this point the study of the workings of the *Agence nationale de la* *sécurité des systèmes d'information (National Information System Security Agency)* created by decree 2009-834 of 7 July 2009 should provide useful data.

Finally, South Korea has taken this route, via its legislation on the development, promotion and distribution of intelligent robots. The order applying this law establishes a certification body which ensures the competence of those building civil robots and ensures the quality of these robots. However, would an additional guarantee of "correct action" not result from adding imperative standards to its artificial intelligence?

Implanting Fundamental Standards and Procedures in the Robot

Let us consider first the most fundamental standards. Here too we shall distinguish between those directly related to the robot's operation and those intended to prevent it from committing an act that would engage the liability of its manufacturer, owner or user. For a military robot there would be a requirement to respect the standards in international laws relating to the law on armed conflicts, to humanitarian law, to human rights and, (why not?), to moral or ethical standards, such as respect for the enemy's religious ceremonies. On this point, the *Manuel de droit des conflits armés* (Legal Handbook for Armed Conflicts) published by the French Ministry of Defense insists on the existence of common rules in the various conventions on this law. Thus, the principles of humanity,[69] discrimination,[70] and proportionality[71] must always be respected by the robot. There then remains the technical issue of installing such standards in the robot's artificial intelligence and especially their interaction with the mission that it has to carry out. Actually, the wise use of the robot would imply that an action contrary to law would lead to its being blocked. These rules would operate to prevent illegal programming and to prevent firing on a civilian or to avoid disproportionate damage. Evidently, such a possibility would require the identification of priority rules and an especially fine artificial intelligence capability so that the robot would be able to distinguish the nuances of the various situations. Thus, as the robot becomes increasingly autonomous and capable of less predetermined behavior and decision-making, the existence of a hard core of hierarchically arranged standards that govern it will prove increasingly necessary. Equally, the establishment of a protocol for the relationship between the robot and the soldier on operations would be indispensable, at least to determine the robot's level of autonomy in decision-making. It might be useful for the soldier to have a means of action that did not depend merely on his own will and sole responsibility, when the robot's assessment of a situation would place the soldier in danger. Here too, the case of settling a conflict of appreciation between the robot and the soldier will have to be taken into account, and this in a highly tense situation, in combat or in a public order operation.

Next comes the procedures. Essential for guaranteeing respect for civil liberties, they will be embedded in the robot's operating system as a security mechanism to prevent malfunction. Surgical robotics make their contribution here by showing that the highest level of autonomy is not always necessary, yet the establishment of standards proves indispensable.[72] Equally, the remote medicine covered by decree No. 2010-1299 of 19 October 2010 published in the *Journal officiel de la République française* (JORF) of 21 October 2010, defines the acts and the conditions of implementation and its organization. Above all, the Commission nationale de l'informatique et des libertes (CNIL) insisted on the measures related to the security of exchanges, the authentication of professionals, data confidentiality, traceability of connections, and the introduction of secure archives.[73] Given these examples, the search for standards both for military and public order-related missions would be necessary for military robots. For these reasons a charter of robotics would seem necessary.

Conclusion: Towards a Charter of Robotics and New Technologies?

The Symbiosis Between the Human Being, Society and the Machine Relies on Standards

The robot has a history and arrives in human society at a time when science allows it to be designed and built, in a society where minds can welcome it. In the process, the current symbiosis, between the human being, society and the machine, would indicate that civilization is evolving into a hyper-rational society. Up to what point can we rationalize society in the name of public order and security, without reducing the natural rights of the human being, for (rational?) purely practical, technical or administrative reasons. The establishment of enforceable international and national procedural standards would provide an answer. This trend is already at work.

Thus, the South Korean government has been attempting to establish an ethical code or a code of practice for this area since 2007.[74] Japan is studying, via its Ministry of the Economy and Industry, a definition of the rules that robot manufacturers should observe to ensure the security of the citizen.[75] In Europe, the European Robotics Research Network (EURON) has identified five principles of robot design that would ensure that the human being retains control. These principles are "safety, security, privacy, traceability and identifiability."[76] Scientist Noel Sharkey demands the establishment of international rules for an ethical use of robots.[77] Finally, the International Conference of Data Protection and Privacy Commissioners voted for the adoption of an international convention on the protection of personal data.[78] A resolution taken to this end indicates which principles a charter for robotics and the new technologies might include.[79] These examples, without forgetting Isaac Asimov's three well-known laws, translate the desire to determine the standards for both the operation and use of robots and their relationship with the human being.[80] Therefore, the creation of national charter on robotics linked to European and international standards does not seem out of place.

Towards a Constitutional Charter for Robotics and the New Technologies?

The creation of a charter inscribed in the foreword to the French Constitution would set out the technical and legal conditions for the use of the robot and would retain the principle that man or an institution are always responsible for the robot. We shall thus propose:

1. A person may always opt to have recourse to a human being rather than to a robot. The use of technology in government must not adversely affect the rights of users.
2. The robot, irrespective of its level of autonomy and artificial intelligence, remains, in essence, a machine that can be switched off using any means, at any time and anywhere by a human being when it malfunctions. Only an actual person or a corporate entity may assume responsibility for the acts he or it commits.

3. The robot must always be identifiable as a robot and not confused with an existing animal or a human being.
4. The principle of the right to technical compliance to certify that the robot is not a hazard. This implies the right to know: the manufacturer, the owner, the technical characteristics, and the software to verify its operation.
5. Right of access to the personal data stored by the robot.
6. The right to use any means to provide evidence contrary to that established by the robot and therefore the obligation to retain all of the data of any nature related to a robot.
7. Consideration of the protection of the robot.
8. Finally, the creation of an independent administrative authority.[81]

This charter would open up a public discussion of the science and its use, and of the reasonable limits that can be imposed thereon without affecting its essence: continuing knowledge of Nature. Such a text would set out the conditions necessary for preserving human nature and its natural rights and would re-establish the link between science and philosophy.[82] Is the scientifically and legally possible always humanly acceptable and achievable?

Notes

1. This exercise requires us to juggle the existing situation and the future potential of robots. To do so, we will assume that these robots will have the full decision-making autonomy that their designers are seeking to give them.

2. We are referring here both to public security and to the security of the person requiring assistance or medical attention.

3. Purely utilitarian civil robots are not involved in this discussion (toys, robot companions, etc.).

4. In other words, the legal regime of each of the liberties introduced by the powers that be and citizens. For example: official arrangements governing religions, fishing, canals, etc.

5. This desire corresponds to a reality. We merely need to note that political leaders take a close interest in crime statistics, clear-up rates, the sense of insecurity and the number of verdicts delivered in various types of litigation. The politician's obsession with results and cost-effectiveness comes into play here.

6. This is only an hypothesis.

7. *The Declaration of the Rights of Man and of the Citizen* of 1789.

8. This is done even without needing to revise the *Declaration of the Rights of Man and of the Citizen* of 1789, one of whose principles is the presumption of innocence. It is not a case of condemning a person, rather of taking precautionary measures, at the risk of standardizing human behavior in the public sphere, by determining what is or is not normal behavior. Thus, the legislator organizes or attempts to organize the identification and traceability of individuals, irrespective of age, whose psychological profile, activities, civil or criminal past pose a risk to society. Video surveillance also makes its contribution here.

9. Both military and civil history show that the State has always sought to use the latest scientific advances. This is therefore normal in itself, but questionable when the use of technological progress turns against the innocent citizen.

10. Question: up to what point can a democratic state make use of a sophisticated technological resource without calling into question civil liberties themselves?

11. We can read on this point the fascinating Comité 5 study "Doit-on adapter les hommes aux armements ou les armements aux hommes" (Should We Adapt Man to Weapons or Weapons to Man), published by the Centre des hautes études de l'armement (Centre for Advanced Armaments Studies), 2009, 45th national session. The question is worth extending to the level of society: Is it up to society to adapt to the robots?

12. For example, photos from roadside radar devices are admissible unless there is proof to the contrary. Let's not forget the many decisions to buy and sell securities (shares or bonds) taken directly by computer software, without human intervention.

13. I am thinking here of the civil Iranian aircraft brought down over the Persian Gulf in 1988 by the US Navy, due to the parameters transmitted by the aircraft's computers characterizing it as an enemy craft, while information from other sources indicated the contrary. See the report of this incident in the *Ouest France* newspaper, 17 August 2009.

14. Would the inactive owner of a fully robotic vehicle be responsible for a machine that operates without his intervention? We shall distinguish between the responsibility of the master of the thing who has programmed it badly or used it for an unsuitable mission and the responsibility of the robot's manufacturer and of all those participating in the robot's design.

15. One can imagine, due to the degree of autonomy, the existence of an area of uncertainty that gives rise to a malfunction that could not be attributed either to the robot's owner, nor to the user, nor to the manufacturer; this area of uncertainty would require its own insurance mechanism so that the victim of the damage could be compensated.

16. This framework is technological and scientific; economic, political and social; religious (reaction of religions to the new technologies, deontology, ethics, morality) and, above all, legal.

17. We think here of the legal framework for access to government documents, the classification of documents, of the control exercised by the Commission nationale de l'informatique et des libertes (CNIL), the French data protection agency, or of the national committee responsible for monitoring compliance with professional practices, especially by the forces of public order and the military.

18. Must the new technologies be the occasion for reducing the guarantees accorded to citizens in the exercise of their liberties?

19. This approach to the robot depends in part on its reality, yet also on the way in which it is imagined, especially in science fiction. We do not conceive of an immobile robot.

20. PP30 is France's 30-year forecast (plan prospective à 30 ans).

21. Is the robot not merely a computer fitted with arms and legs or other form of locomotion?

22. The choice between the two, the form and the method of locomotion, depends on its use.

23. The 16 October 2010 law on the development and promotion of the distribution of intelligent robots.

24. The 16 October 2010 law on the development and promotion of the distribution of intelligent robots, article 1.

25. Ministère de la défense nationale, SGDSN, *Manuel de droit des conflits armés, direction des affaires juridiques, sous-direction du droit international et du droit européen, bureau du droit des conflits armés* (French Ministry of Defense, SGDSN, *Legal Handbook for Armed Conflicts,* Legal Affairs Department, International and European Law Sub-Section, Office for the Law of Armed Conflicts).

26. It would be yet to determine whether it belonged to the public or private part of the army or of any other public authority.

27. Article 528 of the civil code states that: "Animals and things which can move from one place to another, whether they move by themselves, or whether they can move only as the result of an extraneous power, are movables by their nature."

28. The robotic arms used in the car industry, by being fixed to the ground on the company site, present this character of immovable by destination.

29. *Livre 3 Titre 1 Dispositions techniques (Book 3, Title 1 Technical Provisions) (Article L311-1 -1 to L318-4) (Articles R311-1 to R318-8), Chapter I, Decree R311-1.*

30. Thus a concrete vibrator was deemed to be a vehicle (Appeal Court, 12 February 2001, no. 3243, Préfet du Val d'Oise), as was the raft used by an officer to reach the riverbank, a road roller, and even the emergency sled pulled by a member of a ski patrol (TA Grenoble 17 April 1996, Kienle).

31. Decree of 17 June 2009 specifying the list of war materiel and similar materials subject to a special export procedure, NOR: DEFD0908305A. The appendix contains the definition of drones and robots.

32. Appendix to the aforementioned decree, in category ML 10.

33. Appendix to the aforementioned decree, in category ML 17. However, it is only in the list of definitions that this word is defined.

34. This definition, although included in a 2009 decree, would be difficult to apply to the military robot.

35. Decree no. 95-589 of 6 May 1995 on the application of the decree of 18 April 1939 specifying the control of war materiel, arms and munitions NOR: DEFC9501482D

36. For example: battle tanks, unarmored vehicles used to set up or carry a weapon, warships of all types, aircraft, balloons, helicopters, cryptology resources, night vision equipment, etc.

37. Located at: www.un.org/fr/disarmement/conventionalarms.glosssary.shtml.

38. For the latest conventions, see: www.un.org/fr/disarmement/conventionalarms.glosssary.shtml

39. On this issue, refer to the *Manuel de droit des conflits armés* (Law handbook for armed conflicts) issued by the French Ministry of Defense.

40. Marc Galdéano and Emmanuel Gardinettti, "L'acceptabilité des robots dans le combat futur: aspects psychologiques, et juridiques" (The Acceptability of Robots in Future Combat: Psychological and Legal Aspects) in *La robotique en matière de défense et de sécurité: Bilan et perspectives, Laboratoire de stratégie de l'armement, Centre des hautes études de l'armement et Direction générale de l'armement, Ministère de la défense* (Robots, Defense and Security. Review and Perspectives, Armament Strategy Laboratory, Center for Advanced Armament Studies and General Directory of Armaments, French Ministry of Defense), 3c et seq.

41. For example, the organization of a religious procession remains possible in a secular State; the judge exercises control over the decision of the mayor to refuse it.

42. We might consider traffic radar, if this device can be accorded the status of robot, or even the use of mini drones by the police at demonstrations. The Japanese and South Koreans are already thinking about using robot policemen.

43. Refer on this point to the *Manuel de droit des conflits armés* (Law handbook for armed conflicts), published by the French Ministry of Defense.

44. *Manuel de droit des conflits armés,* 3.

45. Article R1321-1 et seq. of the Code de la défense (Defense Code).

46. Article 36 of the Constitution of 4 October 1958, and articles 2121-1 et seq. of the Code de la défense nationale (National Defense Code).

47. See articles L2151-1 et seq. of the *Code de la défense* (Defense Code).

48. See articles L2141-1 et seq. of the *Code de la défense* (Defense Code).

49. See articles L2141-1 et seq. of the *Code de la défense* (Defense Code).

50. Refer to the *Code de la défense* (Defense Code).

51. Article L2131-1 of the *Code de la défense nationale* (National Defense Code), which refers to law no. 55-385 of 3 April 1955.

52. This plan, combined with other plans specific for certain threats (nuclear, toxic, etc.), authorizes an increase in the surveillance and operational resources available to respond to a terrorist threat, in accordance with the level of alert in place.

53. Gerard de Boisboissel, a research engineer at CREC at the St Cyr Coetquidan college, distinguishes between control robots which do not interact with their environment (reconnaissance, patrol, and observation), support robots for materials handling and transport, operational robots performing a defensive action and operational attack robots which may constitute the weapon itself or carry a weapon and, therefore, kill an enemy.

54. Or should we envisage the military using robots specific to public order. Equally, it would be necessary to determine the cross-service protocols between the military and the civil police forces in respect of the use of robots.

55. Since the introduction of the law banning the wearing of any clothing hiding the whole of the face, the concept of public place is now defined in a general, rather than a specific way, in the name of public order. Previously, this notion was subject to circumstantial definitions and linked to a specific area. For example, the ban on smoking in public places or demonstrations. We will thus see the decision of the Conseil constitutionnel (Constitutional Council).

56. Penal code article 706-95, *Interception of Telecommunications* and article 706-96, *The Taking of Audio Recordings and Visual Images in Specified Vehicles and Places.* Thus judicial police officers or agents may, without the consent of the people concerned, "install any technical device

designed to hear, preserve, transmit or record words spoken by any person or persons in a private or confidential context, in private or public places or vehicles, or the images of any person or persons in a private place."

57. For example, the fixed radar units that check vehicle speeds on the public highway or compliance with red lights.

58. For example, an insect robot, whose appearance would make it unidentifiable at first sight.

59. This explains the importance currently being paid to the design of robots to allow the identification of the robot and its operation in relation to its environment. The humanoid form is not necessarily the most suitable.

60. For example, see the article in *Le Figaro,* 12 November 2010, 8. As regards video surveillance, the effectiveness of this tool results from its combination with software capable of identifying, storing and notifying behaviors deemed likely to disturb the public order, such as suddenly raising an arm in the air, assemblies of persons, or running, which do not, however, of themselves constitute offenses. How capable will a robot be of distinguishing between a blameworthy act and a joke that looked like a blameworthy act?

61. An article in *Ouest France*, 17 August 2009, quoting US colonel Thomas Adams, who states that the speed, miniaturization, and the number of robots create a complex environment. Finally, the article quotes Marc Garlasco, an advisor to Human Rights Watch, who would like to know who would be responsible if a robot committed a war crime.

62. See the comparative study of Europe in *Sécurité routière* (Road Safety), press kit, June 2003.

63. This was the decision made after observing other European systems that are only partially automated and retain human intervention, especially in the detection of the offense and the identification of the number plate, in *Sécurité routière,* press kit, June 2003, 19 pages.

64. Refer on this issue to Sécurité routière, press kit.

65. Article L 130-9, Highway Code.

66. This refers to automatic road traffic offense detection center (CACIR), created by decree no. 2004-504 of 10 June 2004, in JORF, 13 June 2004. Thus, "The automatic road traffic offense detection center (CACIR) is a joint service where officials and agents of the judicial police of the national police and gendarmerie carry out their usual tasks. Its jurisdiction extends across the whole of the national territory for the offenses detected."

67. It operates under the authority of the *Procureur de la République* (France's Attorney General).

68. Article L 2312-1, *Code de la défense* (Defense Code)

69. Avoid superfluous wrongs in the use of force. The use of robots would have to, therefore, observe this principle.

70. It consists of distinguishing between the military objectives, civil property, and the civilian populations.

71. Aim to avoid launching an attack that would harm civilians, their property, actions that would be excessive in relation to the advantage that the military action would gain.

72. It should be noted that the current development of surgical robotics already requires the surgeon and the medical team to undergo special training; the presence of an emergency team is required in case of malfunction, that the robot has to have embedded autonomous security mechanisms and a maintenance company has to be used to ensure that the robot is kept in a perfect operational state.

73. See the article on remote medicine on the "News" tab on the CNIL website.

74. Information quoted by *Courrier Internationa*l, 15 March 2007.

75. For example, sensors to avoid collisions, flexible materials and even emergency switches would ensure that a robot did not harm a human being.

76. Quoted in Evan Blass “Guide to Robot Ethics Set for Publication” http://www.engadget.com/2006/06/18/guide-to-robot-ethics-set-for-publication/. Accessed 16 October 2013.

The robot should be: safe, non-hazardous, identifiable, traceable and discreet.

77. Refer on this point to: “A call for international controls on the spread of armed military robots” at www.icrac.co.cc/index.html.

78. The reference is to the 32d International Conference of Data Protection and Privacy Commissioners held in Jerusalem at the end of October 2010.

79. See the CNIL website for the resolution on international privacy standards adopted at the 31st conference in Madrid. This conference proposed the adoption of binding international and national standards.

80. The inspiration for this 20th Century science fiction writer to draw up his three laws came from the editor in chief of the magazine which published his short stories: “1. A robot may not injure a human being or, through inaction, allow a human being to come to harm; 2. A robot must obey orders given it by human beings except where such orders would conflict with the First Law; 3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.” The author would go on to suggest another law as the “Zeroth” law: “A robot may not injure humanity or through inaction allow humanity to come to harm.” How much credence should we give to these laws?

81. We might suppose that the chair of this authority would be drawn from the judiciary and appointed by a committee of representatives from the *Conseil supérieur de la magistrature* (Supreme Magistrates Committee) and from the *Conseil d’Etat* (Council of State). It would consist of members drawn from parliament, civil society, citizens selected at random from the electoral rolls and particularly competent individuals from the mechanical engineering, IT, and electronics fields, as well as from the law. This authority’s mission would be to inspect the certifications awarded to companies responsible for inspecting the software, to ensure the citizen’s right of access, to inspect the companies manufacturing robots and the civil or military user institutions and to guarantee compliance with the procedures in this area. It could take any offense to court and would have regulatory powers and be able to impose administrative sanctions. It would deliver opinions on any topic related to robotics, in voluntary or compulsory consultation with government, members of parliament and other elected representatives, judges and even companies linked with the design and commercial distribution of robots. These opinions would be made public in their entirety, or partially where the national interest was at stake. This authority would have an investigative role. All citizens would have recourse to it.

82. See Paul Virilo, *“Nous sommes dans le culte de la vitesse-lumière”* (We Are in the Cult of the Speed of Light), *Science et avenir,* January 2011, 44 et seq.

Chapter 10
Military Robots and Ethics:
Ethical Problems for European Industrial, Political, and Military Leaders
by Benoit Royal

How might public opinion and the media comprehend robots and the associated issues?

What might be the vision of the military, political and industrial decision-makers regarding the development of robots in current and future crises, taking into account the various technological evolution prospects?

How does the nature of these robots—Remote-controlled, semi-autonomous, totally autonomous—affect these visions?

I will try to simultaneously answer these questions through three major ideas:

1. Our current modern society is genuinely fascinated by robots. This fascination stimulates research and speeds up robotic development since, every day, one finds new possibilities to use them, especially when it comes to preserving human lives.
2. The development of the use of robots alongside men, and especially of military robots aimed at inflicting wounds or at killing, already raises ethical issues pertaining to international laws and to the fundamental liberties which will increasingly be imposed on designers and on political authorities.
3. The "legalization" of Western societies, induced by the refusal of the inevitable and the search for the guilty in an environment highly saturated with media, will sooner or later force political leaders to consider the need to write laws concerning robots.

"Robolution"-the Fascination for Civilian and Military Robots, Increasingly Aimed at Preserving Human Lives

In the *civilian domain,* people are fascinated by all that is linked to new technologies: it is fashionable, new, and talks them into buying. This interest is centered on things which make personal, family and professional lives easier, especially by reducing constraints. When asked "what would be the ideal robot for you?" a majority of people have answered: the baby-sitter robot, the carrier robot, the secretary robot, the cleaning and shopping robot, etc.

Bruno Bonnell (Director of Robopolis, a company specialized in personal robots, and Chairman of SYROBO, the European individual robots association), who wrote a book entitled *Viva la Robolution,* recently declared, "In Korea, I visited schools where the

Disclaimer: The views and opinions expressed in this article are those of the author and do not necessarily reflect the views or opinions of the French MoD or Euro-ISME.

teacher was helped by a robot. It would take the register or be in charge of the gym class while she would concentrate on pupils with learning problems. Robots are going to change your lives in the next 20 years, as have computers. The tool has been the continuation of the hand and, following the same logic, *men are devolving intelligence to robots."*

Beyond their interest at home, they are also – or mainly – increasingly interesting in the security domain. Many ideas have emerged to use convenient and rather cheap unmanned aircraft to observe fires, large open spaces, bridges, high voltage lines, maritime areas, etc. Their employment is indeed still very limited since the laws concerning flying objects dramatically limit their use (to avoid the risk of collision with aircraft or people on the ground), but the evolution of safety technologies should progressively help reduce these limitations.

In the Military Domain

The combat robot fascinates as much or even more than the "domestic" one, but the issue of its freedom of action is always present. The current interest is mainly focused on the "flying robot," as unmanned aerial vehicle, the most widely used during conflicts and the one for which most development are planned. The media speak about it a great deal:

1. Sara Daniel, "The UAV War" *Le Nouvel Observateur,* 27 May 2010.
2. "Do Ground Robots Represent the Future of the Armies?" *La Tribune,* 25 May 2010.
3. Pierre Grumberg, "Armies Put a Big Bet on Robots" *Le Télégramme,* 30 May 2010.
4. "Letting UAVs Make War for Us." Slate.fr, 13 June 2010.

In the United States, many books about robots with highly significant titles were published in 2009:

1. P. W. Singer, *Wired for war: The Robotic Revolution and Conflict in the 21st Century,* (Penguin Press).
2. Ronald Arkin, *Governing Lethal Behavior in Autonomous Robots,* (CRC Press).
3. Wendell Wallach and Colin Allen, *Moral Machines: Teaching Robots Right from Wrong* (Oxford University Press).

The main use of these robots in the military domain is to reduce combat constraints. For the French Army, the stake is to intervene in complex theaters of operations while reducing the risk of human losses. In that respect, a member of the French DGA (the French Procurement Agency) explained: "We have to be able to rapidly deliver these technologies to our soldiers, and to speed up dual research with the large robotic laboratories." The main reason for this passion is that robots spare the tears, blood and sweat of the soldiers by carrying out many missions, those that the Americans call the "3D:" Dangerous, Dull and Dirty.

That being said, let us not fantasize about the word "robot," that the Americans prefer to call UGVs (Unmanned Ground Vehicles), USVs (Unmanned Surface Vehicles) or UUVs

(Unmanned Underwater Vehicles): those which are currently in service are still remotely controlled by an operator. It is worth noting that, in France, airmen refuse to speak about "planes without pilots." They demand that we speak about "planes without pilots aboard," since UAVs indeed have someone who pilots them.

Examples of Missions Carried out by UAVs and/or Robots:

1. The spotting and defusing of mines: there has been a major breakthrough in the field of ground robots dedicated to the spotting and defusing of improvised explosive devices, the home-made mines which currently cause 70% of the losses in Afghanistan. Where you used to need a mirror and a lot of courage to observe what was happening inside a house, you now have small robots (such as the Inbot, weighing less than 2 kilos [4.5 lbs], with three cameras and four wheels, developed in France by ECA) which see in the dark, listen and send their data to an operator located some 100 meters away. Another robot can then be sent to destroy the device.
2. Painful and tiresome tasks: The first robots able to carry the backpacks (such as Big Dog) should enter into service in the coming years. We are also beginning to consider the development of robots that carry stretchers.
3. The so-called "dirty" missions. There is no lack of ideas to find jobs to robotize for these very dangerous missions. The Army is for instance working on systems able to automatically draw a map of biologically or radioactively contaminated areas.
4. War missions: the specific case of attack UAVs. Ever since 9-11 and the war in Iraq, flying machines initially designed to collect intelligence have become killing machines used to "suppress" terrorists and those designated as "illegal combatants" by the United States.

Unmanned aircraft have become, as former CIA Director Leon Panetta pointed out, "the only game in town," the only efficient weapon we are supposed to have against Al Qaeda. There are more than 300 types of UAVs today. They range from the micro-UAV, the Nano Flyer which only weighs a few grams up to the Global Hawk which is as big as an Airbus. Imagination in military technology knows no limit. The point there is to suppress enemies without jeopardizing the lives of the soldiers. In addition to that, UAV missions are less expensive than those of the "conventional" Air Force. Unmanned aircraft have become the main investment area for the US Air Force. The United States has about 7,000 UAVs. According to General Norton A. Schwartz, the Chief of Staff of the Air Force, the US Air Force has trained more UAV operators than pilots for the first time ever in 2010. Andrew, a young UAV operator working on Creech Base in Nevada explained, "This is a crucial step in military history, comparable to the discovery of [gun] powder or the nuclear bomb. War will never be the same again." A journalist recently commented about this phenomenon: "Battles are increasingly conducted by staff personnel, trained on video games, who almost only drop bombs during working hours, using only their screens, on an enemy located dozens of thousands of kilometers away, before going back home in time to prepare the dinner for their kids."

UAV war also raised the enthusiasm of all parties represented in the US Congress. The press mentions the passion of the current Vice President Joe Biden, who even thinks that instead of waging a counterinsurgency war against the Taliban in Afghanistan, which costs a lot of human lives, the US Army should only focus on those computer-assisted strikes to destroy Al Qaeda's HQ.

To summarize the first part of this article, one can say that the potential represented by UAVs and robots for the civilian world as well as for political and military leaders, causes real fascination and not mere interest. However, in the military domain, this fascination and this interest are increasingly confronted with rejection, fear and disgust when one looks from the side of those who suffer from their consequence or perverse effects.

Only the mention of extreme cases of armed UAVs used in the Afghan conflict, is enough to get some people to start speaking out—increasingly loudly—to denounce the perverse effects of the UAVs.

In Pakistan, the main target of armed UAVs, these systems have been nicknamed "the wasps," and the populations of the tribal areas scatter as soon as they hear this distant lawnmower noise which characterizes the flight of UAVs. Resentment against them is growing because of serious mistakes and of the massive collateral damage they cause. The Pakistani Prime Minister and Chief of Staff have declared that these bombings were "counter-productive." Pakistani newspapers condemn these "underhanded" attacks led by invisible machines that are only sometimes announced by a slight rumbling noise. "Drone" has become a pejorative word in urdu and Pakistani rock bands write songs about an America which has lost its honor. The "accurate" and "efficient" strikes are perceived as "cruel" and "cowardly" by the Middle-Eastern press.

In Pakistan, like in Afghanistan, stories of tragic blunders inevitably create new insurgents, and military and political leaders do not discard the media effect induced by the massive employment of "killer" UAVs or by the consequences of targeting mistakes.

As with the employment of other weapons, the use of such lethal equipment as the armed UAV cannot be envisaged without an ethical approach comparable to that applied to conventional engagements.

Ethical Questions Pertaining to International Laws but also to Fundamental Freedoms

In Civilian Societies Outside Combat Areas

The arrival of robots in civilian society (for instance for surveillance purposes) is beginning to raise legal issues, since these robots record and store all types of data. Some judges consider that it will rapidly induce problems regarding the protection of private lives and the legal value of evidence collected in that way. Just remember the first debates when the first surveillance cameras were put in place.

In the US, some people have started wondering whether the Second Amendment of the Constitution will allow the ownership and use of robotic weapons. This question might seem far-fetched, but there has been an example in Atlanta where a bartender has built an "anti-tramp robot" with an infrared camera, a spotlight, a loud-speaker and a water-gun. He uses it to push away tramps and drug-dealers who try to settle in the parking lot of his bar.

In Combat Areas

The massive arrival of mechanical systems will raise issues, since the emergence of these robots on the ground also questions some of the most fundamental notions of the laws of war.

1. Let us remember that no mechanical system can distinguish the difference between friendly and hostile behavior or between a civilian and a soldier. The Geneva Convention appeals to "common sense." Try to download THAT into a computer! In South Africa in 2007, due to a "software problem", an automatic air-defense gun killed nine soldiers during a training session. *Conducting the investigation and pronouncing a judgement on such accidents raises new questions.*
2. Answers to questions—which are crucial to military and politicians—about the proportional nature of retaliatory actions or the responsibility for those actions: in case of blunder or technical malfunction, who is responsible? The designer? The manufacturer? The user?

For the time being, the US military confirms that they permanently keep "the human in the loop" for the final decision to open fire. But the border is slippery and, with the development of technologies and autonomy, humans can rapidly find themselves "on the loop" or even "far above the loop." The user will then have to choose between trusting the machine and running the risk of a blunder, or check the data and downgrade the efficiency. These crucial questions, which pertain more to the ethical than to the technical domain, have not been answered yet.

Considering This, Where are We From an Ethical Point of View Regarding the Employment of UAVs

In France, the ethical reflection is first of all philosophical. The point is to defend values in which a country recognizes itself and, since the enforcement of ethical rules in combat has a positive influence when fights take place amongst the populations, one can consider that we have to be ambitious in that domain. It is significant to see that one of the very first official documents regarding the use of armed UAVs and robots published by the French Ministry of Defense already associated the induced strategic stakes to the ethical reflections it causes.

In the United States, the legal advisor of the State Department borrowed Hillary Clinton's "smart power" catchphrase. This concept covers the smart use of all existing assets, including technology, human rights, and international laws to justify the use of

UAVs and their positive effects. It is the search for this added value in the communication action which is desired, beyond communication on the actual results. Some academics who specialize in these subjects do not hesitate to ask the US film industry to give a more pleasant image of UAVs (by fighting for instance against the negative image conveyed by the *Terminator*). As one can see, the more important point is to develop communication strategies rather than ethical rules.

The Refusal of the Inevitable and the Search for Responsibility in a Media-Saturated Environment

The Refusal of Chance in Western Societies and its Immediate Corollary: the Search for Individual or Collective Responsibility

Currently, Western citizens increasingly discard the notion of "fortuitous event," chance or bad luck for several reasons (fortuitous meaning "happening by chance" and, in French legal terms, "which frees the apparent perpetrator of the damage from any responsibility"). On the one hand, technological advances and the progress of our knowledge over the past century have led us to dream of finding a cure to all human problems, have made accidents unacceptable and have induced us to refuse the fact that life can end at an early age as we now live long. The Western way of life automatically leads to rejecting risks, and especially that of losing lives.

On the other hand, one can observe a social phenomenon called the *private domain ideology* by Professor Hude, which tends to overwhelm everything else. It consists in a marked rejection of institutional power, inducing excessive media attention on all facts which could place this power in a difficult situation. It triggers a systematic search for somebody else's responsibility in all daily events, even when said events are unpredictable or when they have natural causes (why has the hurricane or earthquake not been foreseen by the weather services?). This determinist development in our societies needs to be taken into account.

Consequently, when an incident or accident causes the injury or death of a beloved one, *the very idea of fate cannot be accepted any longer,* and the loss becomes unbearable. This questioning is often perceived as a necessary catharsis aimed at trying to mitigate the pain. The "legal" process is hence launched in order to ward off emotion and to respond to the pain. The loss of religious feeling, which helped accept "fate," further amplifies this phenomenon. It is the role of the judge to decide. This fuels the *legalization* phenomenon in our society.

Two emblematic examples:

1. The loss of 10 soldiers on 18 August 2008 during an ambush in Afghanistan in Uzbeen valley was followed by a legal action against person or persons unknown presented to the Paris Armed Forces Court for "having deliberately endangered the lives of other people." Mrs. Alexandra Onfray, public prosecutor at the Paris Armed Forces Courts, wrote: "justice intervenes in areas which are at the heart of

the military profession and could exercise a pressure which had never been experienced or even considered in the past."

2. More recently, firemen, whose work is to provide assistance to the populations, have also been subject to search for liabilities and complaints for their relief actions, while they risk their own lives to save that of the populations. Claims such as "they did not arrive quickly enough" or "they made a wrong choice" are now heard.

In that framework where the inevitable is no longer accepted and where people demand compensation, one can see that legal prosecutions for mere carelessness now applies to all domains of human activities, and the military domain is not excluded. How could we think that the arrival of robots (both civilian and military) could be excluded from this?

The Media-Saturated Environment Leads to the Need for Increased Transparency in all Military Actions

Media saturation comes along with another fact of our Western societies: the citizenry is very emotional. This emotionalism is mainly perceptible when it comes to limiting freedoms, to issues of dignity, and to the interpretation of justice or of the law.

These realities mean that any violent action conducted during an operation which could be perceived as violating the law is likely to immediately intrude into the daily life of populations at peace, comfortably sitting in their living-rooms and watching evening news programs, thus simultaneously evoking the same emotion in thousands or even millions of fellow citizens. As early as 1999, General Charles C. Krulak, Commandant of the United States Marine Corps, had highlighted the risk generated by this phenomenon in an article entitled "*The Three-block War.*" He described the phenomenon as "the Strategic Corporal." In a nutshell, he explained that any misbehavior committed by the most junior corporal on the ground could be almost instantly denounced in the international press and could trigger reactions likely to go as far as the questioning of the strategy of the operation itself.

Through media of this type, populations are hence able to have a weight and an influence on political decisions, which could *in fine* modify the employed strategies and also induce politicians to try to identify and punish those they feel are responsible. Besides, wherever it happens, when broadcasted by the international media, any breach of the law or of dignity touches public opinions and makes the public react. People use their legitimacy to express their disapproval in the streets and in the press and, when they can, at the ballot boxes.

As an example of this phenomenon, in September 2009, asummary of a blunder committed by a German Colonel in Afghanistan was published in the German newspaper *Bild*.

On 4 September, NATO bombed, upon request from German Colonel Georg Klein, two tanker lorries stolen by the Taliban near Kunduz. The German officer feared that both vehicles might be used as rolling bombs.

Bild, relying on an Army report and on a video, states that Colonel Klein ordered the attack despite the fact that he could not be absolutely certain that there were no civilians nearby, which complies neither with the NATO Rules of Engagement nor with the directives given by General Stanley McChrystal, the Commander of the international forces in Afghanistan.

At the end of October, General Schneiderhan had declared that Klein's name had been cleared by a NATO report, and that he had "no reason to doubt that the German soldiers had acted in an adequate military fashion, given the mandate of the United Nations and the difficult solution." However, a NATO military source stated that US fighters had twice offered to make a "show of force" to intimidate, while the German commanders had demanded the use of force. Bild also affirms that former Defense Minister Franz Josef Jung had known about possible civilian victims long before the time he publicly acknowledged.

The direct consequence of this serious blunder was the forced resignation of the Chief of the German Joint Staff and of a Defense Minister in November 2009, and the officer who made the decision still has several legal proceedings pending.

The emotion caused by the vision of the human consequences of military deployments—for our own troops, for the opponent, or for the innocent population—was made even more vivid with the refusal of the inevitable and the demand for compensation which mechanically increases the risk of exposure for our soldiers. This requires transparency in our actions. That being said, in the report of New America Foundation, a think tank which specializes in counter-terrorism, two researchers (Peter Bergen and Katherine Tiedemann) considered that one third of the casualties UAVs produced were innocents. For instance, the successful attack against Baitullah Mehsud (one of the most powerful Pakistani Taliban leaders) in August 2009 had been preceded by some 15 other bombings which killed many civilians by mistake. The consequences of a false denunciation or of an intelligence mistake can be dreadful, whatever the means of delivery of the bombs (UAV or aircraft manned by a "flesh and bone" pilot).

Beside the induced human consequences, the improper use of military robots increasingly excites reactions against their users. It makes them look bad by showing them as users of a lethal weapon who do not even dare take the risk of using it themselves. Sooner or later, they will face criminal prosecutions.

Peter W. Singer, a military expert at the Brookings Institution who wrote a book about the robotic revolution in the art of war, goes even further by considering that the use of killer robots should absolutely lead the international community to ask some legal, moral and political questions such as whether *it is constitutional to destroy one's enemies by clicking on one's computer mouse?*

Conclusion

Technological progress in the design of robots seems to gain exponential momentum, but our institutions cannot keep pace with it. The laws of war, as defined in the Geneva

Convention, have been written at a time when people listened to 78 rpm records. How could these laws for instance be used for those who use 21st century weapons such as the U.S. MQ-9 *Reaper* UAV, deployed at very long distance against an insurgent who is himself violating international conventions by fighting from a hospital?

It thus seems increasingly necessary to try to define a legal framework that will determine the ethical framework of the use of these new technologies since the passion caused by the arrival of robots will not survive long after the first blunders (for military robots) or first malfunctions (for civilian ones). Regarding the latter, let us remember the debates in France after the malfunction of a speed regulator which had caused a serious car accident.

*To the question "will the law be able to follow the pace?" it is not preposterous to think that the citizens will be the first to ask or even demand that they do follow this pac*e.

On the other hand, it also seems necessary to rapidly consider limiting the dissemination of these technologies because we should not forget that, sooner or later, a rogue opponent—or state—might also have access to them and find a way to attack us with our best weapons. This is the reason why we need to develop military and domestic security strategies which will rule the use of these sophisticated technologies and which will also take into account the way our opponents might try to use them against us.

There is therefore a real strategic stake linked to the design of the future generation of robotized weapons, which could induce the drafting of a new Additional Protocol to the Geneva Conventions. It would then define their framework of employment while limiting their use to a small number of countries.

To conclude on ethical considerations, it is worth reminding ourselves over and over again that international laws have been developed around the idea that even war cannot be prosecuted with any type of method. In this extreme situation where everyone is trying to kill the enemy before being killed, laws and customs apply in order to govern combat and to make sure that it is honest, fair, and proportionate. These rules have been compiled in texts which recall that, even in the toughest fights, in the design of the most complex techniques, in the development of the most sophisticated robots, a little nucleus of that so precious and so dearly obtained civilization must remain. It must be preserved at all costs. If we fail, we will lose our humanity and our most essential values. It is our duty to work on that and we, the military, being the first stakeholders in war and the first users of these weapons, must also be the first to participate in this reflection.

Chapter 11
Autonomous Robots:
The Irreducible and Complementary Place of Officer's Ethics
by Dominique Lambert

Let's start, first of all, by putting the ethical problems raised by military robots back into a wider context. This will show in fact that our thinking could be fruitful for a wide spectrum of fields of human activity well beyond the sphere of military ethics.

Ethical problems, underscored by the robotization of weapons systems in military operations, come up in every situation where man has delegated the power to make decisions and take action to a machine, or more broadly to a system that executes, on a physical or computer substratum a set of procedures controlled more or less rigidly by rules. And these situations are becoming more universal in our society.

This delegation of power and action, which implies granting total or partial autonomy to these machines or complex formal systems, appears as a corollary of human limits in emergency situations calling for fast action, or when the amount of information that must be handled largely exceeds the usual capacity of the human brain. Such situations are actually quite common, for example, in the practice of intensive care or emergency medicine. In fact, the need to quickly integrate a lot of data on the patient in distress and take a virtually instant decision on what action to take, has led to the development of a series of decisional and action support programs, which, in a sense, robotize the practices of the Emergency Room (ER) physician. This robotization of ER decision-making support demands inclusion of legal and ethical parameters in software which helps physicians to choose a course of action and to assess the legitimacy and the pertinence of the risks to be taken.

Computer-aided decision-making is also used in financial portfolio management and in determining economic strategy in complex contexts where reaction speed is essential and imposed by stochastic market fluctuations and key players who are not always rational. In a somewhat different but still fairly close way, we find this kind of tendency to resort to robotized systems to support legal or academic rulings. For example, in the case of a very big competitive examination, the need to rank a large number of candidates (sometimes several thousand) very quickly (in just a few days) leads juries to leave their deliberative power in the hands of IT systems which automatically decide the students' fate by processing a great many complicated criteria, which an ordinary jury would have difficulty weighing in a perfectly equivalent manner for all candidates in a reasonable amount of time.

As we have seen, all these situations demand very fast acquisition of information, a huge amount of data processing, and surprisingly rapid actions and reactions. But these situations are also bound by practically zero tolerance for errors (e.g. medical errors are not tolerated and military missions without casualties are demanded). This naturally leads to computerization and robotization (and by this term I wish to emphasize that some systems automation is inevitable) to compensate for human limits and to meet socio-political demands, or even the constraints of the academic calendar.

All of these situations raise practically the same issues, due essentially to giving up human prerogatives to a machine in the name of safety and efficiency. This ultimately means implementing a formal system, i.e. establishing up a step-by-step, finite procedure controlled by rigid rules set in advance. Let us also note that quite similar issues are raised when the prerogatives of states are delegated, for the same reasons as those we have mentioned, to human groups that behave like quasi-autonomous systems free of true political regulation, that are driven solely by the profit motive, as is the case (1) of certain financial companies, or (2) of private security companies, described in the so-called "Montreux Document" of 2008. Very characteristically, these two situations constitute present-day phenomena that threaten our political and economic systems. In her book entitled *Libertés et sûreté dans un monde dangereux ("Freedom and security in a dangerous world")*, Ms. Delmas-Marty, a renowned legal expert, professor at the Collège de France, and member of the Académie des Sciences Morales et Politiques, perceptively analyzes the erosion of the power of states who, to deal with consequences of globalization, subcontract law enforcement and security to private groups.[1] Professor Philippe de Woot, renowned economist and member of the Académie royale de Belgique (Technologies & Societies class) has brought out the hazards of economic or financial practices that are totally free of political control, stemming from shareholders groups whose behavior can be described as a profit mechanism that lies pretty much outside of society, politics, or the law.

Now that I have widened the scope of the autonomous robot problem by examining the basis of similar issues that have become universal in a society as complex as ours, I suggest some areas for thought specifically dedicated to military robotics.

In a democratic regime, any time a human group starts to gain significant independence from society at large, or any time a sophisticated technological system becomes more independent of man himself, it must be regulated by a precise legal and ethical system in order to avoid breaking the bonds that are vital to the cohesion of society. In the context of our conference, the exact problem is to know what controls can be exercised in the case of armed robots with effective decision-making autonomy.

I would now like to analyze the position on this subject taken by Ronald Arkin, which consists in seeking to implement ethical constraints in the very computer architecture of the robot.[2] At first, this sounds like a very good idea and, in the situations that I have mentioned above like decision-making support and emergency medicine, this type of ethical software has, in fact, already been proposed. Building in an "ethics fuse" that blows if the protocol automatically proposed by the software would break moral rules is obviously better than nothing. However, the problem that comes up here is to know whether we can ultimately formalize the process of ethical judgment, i.e. completely and adequately translate it into a sufficiently sophisticated formal language. The crux of the matter is the central philosophical question raised by artificial intelligence: is it possible to completely or sufficiently imitate human thought using powerful digital computers? (The question could in fact be extended to other types of computers such as quantum machines or hybrid biological-digital systems.)

To develop a robot based on ethics software, one starts typically by boiling down ethics to law, then adopting a purely procedural representation of the law, and finally seeking to implement the procedure in the form of an algorithm. But this is relevant only if the moral dimension can be reduced to a legal dimension. And yet we know this is not the case. It is rather the other way round: there are a series of moral principles which often prevail over the legal institution and in fact underpin its architecture. Consequently, the proposed "ethical" robot is ultimately thinkable only if ethics can be completely formalized and computerized.

However, we cannot take this track, for we do not think it possible to completely formalize ethics. In logician's terms, we could state this by saying that the ethical decision-making process is not completely algorithmic. Or we could argue that the intuition which governs our judgement is much too rich to be expressed by a step-by-step procedure in finite time. In other words, ethical decision-making is incalculable. Historically, the famous mathematician, jurist, and philosopher Leibniz dreamed of such a procedure written in a universal language, the *characteristica universalis.* But we do not think this line of reasoning goes in the right direction. Why?

One part of the answer is the following. In medical ethics, in military ethics, or more generally in decisional ethics, the limits of formalization are in part linked to "conflicting goods." Two goods of the same importance, or two laws codifying these goods, may pertain to the same situation. Choosing one conduct means denying the other and *ipso facto* taking an unethical position in contradiction with the other "good," thereby blocking the decision-making process. This is a well-known situation with no easy way out, even if one tries to choose "the lesser of two evils." Choosing one good over another calls for deliberation, which must take factors into account which go beyond strictly formal information. Canadian philosopher Michel Métayer sums it up well in his work *La philosophie éthique. Enjeux et débats actuels (Ethical philosophy. Current challenges and debates):*

> In cases where there is a conflict of values, the essential problem lies in weighing up the opposing values, in judging which value is more important. [However it should be noted that] each concrete situation is always particular and complex. Moral judgement must consider the particularities of the context where it applies.[3]

And yet it is this very complexity and the infinite subtlety of the details of the context which mean that a computer program (even if it uses legal criteria or advanced logic) cannot replace a human decision-maker, whether judge, or doctor, or military officer. This contextual complexity stands out the most in current military operations, where the boundary between combatants and non-combatants is blurred and where urban combat constantly mixes civilians and military personnel, preventing real discrimination among subjects of law. Hence Marc Garlasco of *Human Rights Watch* is right in saying, "You can't just download international law into a computer. The situations are complicated; it goes beyond black-and-white decisions."[4]

If ethical decision-making is not completely translatable into purely algorithmic or formal terms, then an irreducible place must be kept for the human decider; he or she cannot be left out of the loop. The officer's role thus remains irreducible, for it is he or she who must in good conscience end indecision and accept or refuse the use of the weapons borne by the robot. And it is also the role of one's conscience that cannot be entirely formalized.

Even if we took a purely naturalistic or reductionist standpoint that the conscience could be explained by the activation of neurons, our problem would not be solved, because even this purely naturalized consciousness could not necessarily be imitated by a digital machine, or its workings by an algorithm!

One must then consider both an ethics *for* or in the robot, *and* at the same time, the fundamental ethics of the officer who remains the decision-maker on use of this technology. One might then imagine building formal limits based on law *into* the robot's software (as Ronald Arkin proposes), such as *jus ad bellum* (criteria to be consulted before engaging in war), and *jus in bello* (acceptable wartime conduct). But since ethics and law are not the same thing, it is important to set aside a place for mediation, for the officer's ethics go widely beyond the principles implemented in the software. These ethics are ultimately based on respect of human dignity (friend or foe) as General de Lapresle reminded us a few years ago during a colloquium chaired by General Cuche, and translated into codes and deontology that must absolutely not be confused with law.[5]

This rediscovery of the irreducible place of the human decider is echoed by the judge who cannot be simply the mechanical executor of a procedure but who must remain a real judge, judging according to justice. The same goes for the professor, who must retain the privilege, the academic freedom, to take a decision in good conscience when he sits on a jury, based on his assessment of the student's situation and of the fundamental values that underlie her or his ethics.

Our position might spark one major objection. Might not keeping the officer's ethical and decisional role in the procedure for engaging an armed robot result in less efficiency and longer reaction time, which could be fatal? Let us note that this role is not necessarily required in all operational situations. The officer may decide (but reserves the right to go back on this decision) to opt for an automatic reaction mode, for example, in the case of a robotized anti-missile defense system (detecting incoming hostile vectors and destroying them). But we must remain aware that an ultra-fast, virtually instant response is not always (and is even rarely) the best decision in a complex ethical situation. It is often better to have decision-making time and acquire additional information that can sometimes clarify the situation. In military ethics or international diplomacy, a lightning-quick reaction is not always a sound one.

Our position comes down to this: when armed robots may be engaged in combat operations, an officer must be standing by as a responsible decision maker. This of course implies intensified ethical training of future officers specialized in this robotic environment. But more is needed. Upstream of the engagement, it is important that the officers know exactly what the ethical software in the armed robots contains, so that they understand the scope but also (and especially) the limitations of these instructions, for overconfidence in the computer's capacities could have disastrous consequences. My refusal of making armed robots radically autonomous is not solely based on the epistemological argument that ethics cannot be fully converted into an algorithm.[6] It is also based on the fact that an autonomous weapon dehumanizes conflict. However, the current engagement of troops in peace-keeping and anti-terrorist missions can succeed only if the troops contribute to building trust with the local population, and contribute to humanizing situations which in fact are marked by distrust and dehumanization. In my view, a fully autonomous armed robot goes against this pacification doctrine. Any decision-maker who hands over powers to a completely autonomous robot whose powers surpass him or her, should remember the words of the philosopher Dominique Janicaud, former professor at the University of Nice, who argued that "The utopia of surpassing the human being is full of inhumanity" and that we cannot do without "preventive humanism."[7] My refusal of making armed robots radically autonomous also stems from the risk of individuals divesting themselves of responsibility. Some people may be tempted to engage autonomous armed robots and then act as if they had no more responsibility for them. It is easier to voluntarily forget your responsibilities if you are distanced from them by the robot's autonomy.

In conclusion, my position is, to be clear, based on an anthropological perspective which, notwithstanding manifestly algorithmic aspects of the thought process and its decisional mechanisms, does not see how all the richness of human thought can be described by a digital machine, or how calculations could be used to exhaust and dominate the infinite subtlety of the contexts in which ethical decisions are taken. My position is also based on the conviction that the officer's ethical role, with his or her moral force, his or her judgment and his or her own values, is essential for democratically conducting peace-keeping, security operations, and law enforcement.[8] If this role was totally delegated to autonomous structures, whether machines, robots, or private military and security companies, something would be lost from democracy and our essential humanity would be eroded. Keeping a place for the military decision-maker in an armed robotic system would, in my view, help foil this tendency to dehumanize security, the economy, law and more generally globalized society, as I suggested at the start of my talk. Dehumanization would prove dangerous for the balance and coexistence of societies at the planetary level.

Notes

1. Mireille Delmas-Marty, *Libertés et sûreté dans un monde dangereux,* (Paris, 2010).

2. Ronald C. Arkin, *Governing Lethal Behavior in Autonomous Robots,* (New York, 2009).

3. Michel Métayer, *La philosophie ethique. Enjeux et debats actuel.* (Quebec, 1997), 8. (translated from the French by the Editor).

4. Cited by P.W. Singer, *Wired for War. The Robotics Revolution and Conflict in the 21st Century,* (New York, 2009), 389.

Chapter12
The Ethical Challenges of Unmanned Systems
by George R. Lucas, Jr.

In this brief essay, I wish only to make a few clarifying remarks, because I believe there is a great deal of confusion and even misinformation in the public domain about what systems we are talking about, about what we are trying to use them for, and especially about the resulting ethical, legal, and social issues that are properly raised regarding each of the several different kinds of unmanned systems we are considering.

For their part, many scientists, engineers, and military personnel working to develop unmanned systems for military uses also find the ethical, legal, and social issues interesting, but are suspicious of people like me, because they have largely experienced that the people working in fields like law and ethics tend all too often to be ignorant obstructionists, who simply find fault with what they do or with what they are attempting to build without even the least bit of genuine understanding of them, their organizations, their activities, let alone about the systems they design, build, and operate. I myself happen to come from a family of engineers and military officers, and for several years I worked as an intermediate-energy particle physicist at the NASA Space Radiation Effects Laboratory in Newport News, Virginia, before (as I like to say) I decided to chase the really profitable salaries in philosophy. My own experience, coming from that background, is that scientists, engineers, warfighters, and defense industrialists regard ethicists as scientifically illiterate, nay-saying, fear-mongering Luddites who just get in the way of others who are simply trying to defend the nation and sustain the rule of law in international relations.

So, in response to these legitimate concerns, I would like to begin by laying out a very clear and simple moral principle, one which I believe when anyone hears it and understands it, will find no reason not to give their unqualified intuitive consent. This is something that a young colleague of mine has labeled “the Principle of Unnecessary Risk.”[1]

Here, in a brief summary, is what this principle holds: We, the public (including scientists, policy makers, defense contractors, and philosophy professors...whomever) have a *moral duty to provide the members of our security forces with every protection, and every avoidance of unnecessary risk of harm we can offer them in carrying out their duly assigned and authorized activities in defense of civil society and the state.*

It is possible that some readers may have trouble understanding this principle, and wonder, in any case, what this principle has to do with unmanned systems. The answer is, “everything.” This is the fundamental principle that explains, and justifies, our desire to develop, build and deploy these systems, as well as undertake a number of other efforts to help make our duly authorized and legitimate security personnel— – be they domestic police, federal law officials, military personnel, intelligence and clandestine personnel, border and immigration forces, and Coast Guard— – safer and more effective in carrying out their duty of defending our nation, our society, and cooperating with the military forces of other law-abiding nations in upholding the rule of law. Let me illustrate how this principle applies first to unmanned, remotely piloted or controlled systems, and then turn to the ethical questions raised by increasing the degrees of autonomy in such systems.

Most of the public's ethical anxiety and hand-wringing has been with respect to "drones," and to what they see as "killing by remote control." We sometimes hear some incredible things put forward as reasonable views: for example, that these unmanned systems are "evil" and "unfair," because they do not give the enemy or adversary a chance to fight back against them. Others complain that these systems are like the "Death Star" from the Hollywood movie "Star Wars," raining down death and destruction indiscriminately from the sky on innocent by-standers. Finally, more sophisticated critics worry about using unmanned, remotely-piloted systems to carry out assassinations and targeted killings of a democratic nation's enemies and adversaries without "due process," and often also that such killings are carried out by non-military personnel, frequently within the sovereign borders of nations with whom our own nation is not formally at war. That last item raises some legitimate and important concerns. Otherwise, most of these objections are utter nonsense, and not supported by the evidence.

Unmanned systems have been unfortunately involved in causing the death of noncombatants. So have manned systems, and combat ground personnel. In all the instances that are not due to criminal negligence or recklessness, these deaths of noncombatants are always regarded as tragic and regrettable mistakes, or unavoidable (but necessary and proportionate) collateral damage when hitting high-value targets. But from all the data we have, the number of such incidents, the numbers of innocent lives lost, and the degree of so-called collateral damage inflicted by remotely piloted systems has been far less than what normally arises from manned systems and ground troops that would otherwise be employed in such missions. RPVs ("remotely-piloted vehicles" or "drones") are remarkably accurate, discriminate, and proportionate in their deployment of force, far more so, on average, than the manned systems or combat operations they have come to replace. There are all kinds of reasons for this, including their ability to "loiter" around targets, and wait for the ideal moment to strike, while taking time and care to be as certain as possible of the identity of the targets.

This is in large part a result of taking the human pilot out of the cockpit, and placing him or her at a remote distance from the weapons delivery platform (for that is what a *Predator* or *Reaper*, just like an F-22, actually is: by itself, it is merely a machine, a lethal-weapons delivery system). And here is where we encounter the "principle of unnecessary risk:" if that pilot or operator is engaged in an authorized, legal, and otherwise morally legitimate mission against our nation's adversaries and enemies, then the mission does not suddenly become "illegal" or "immoral" just because the human is no longer inside of, or physically carried by, the weapons system. The only morally significant thing that changes, is that the degree of risk of harm to the operator is reduced nearly to zero. And, all things being equal, we, the public, whom they are defending, have a moral duty to provide that reduction of risk to our war-fighters and combat personnel, as well as to our intelligence and domestic security personnel. We especially owe it to them, if by reducing the risk of harm coming to them, we make them and their weapons systems in turn more effective, accurate, discriminate, and proportionate in their deployment of deadly force against enemy targets.

None of this would be true if the missions themselves were unauthorized, illegal, or immoral. If a nation's security forces (its military and police, for example) were engaged in persecuting its own citizens by killing, torturing them, or robbing them, or forcing them to work as slaves, then such actions would be immoral as well as a violation of international law, whether or not the force used to accomplish these terrible ends was inflicted directly by manned systems and ground combat troops, or remotely by unmanned systems. But then, again, it is not the system used, but the moral appropriateness and legality of the activity or mission, which is always the proper focus.

That might lead us to conclude that remotely operated, unmanned systems themselves raise absolutely no new moral or legal questions at all, other than the morality and legality of the missions or objectives for which they are deployed. That is almost correct, and surely shows the depth of the confusion and "technophobia" that have infused the moral and legal debates about unmanned systems. The one point to be noticed is that the development and use of such systems considerably enhances any nation's ability to carry out such missions.

In the spring of 2012, the U.S. and European public first learned the news about a Saudi "double agent," who coordinated with the American CIA in heading off a planned terrorist bombing of a civilian airliner, and then provided intelligence that led to the targeted killing through a "drone strike" a few weeks later of Fahd al-Quso, Al-Qaeda's leading operative in Yemen, who had masterminded this operation, and who is suspected of planning the attack on the USS Cole in 2000. The action, and any moral or legal doubt that some citizens have over such covert actions, are not new, nor are such acts of covert retaliation by the clandestine services generally. Intelligence and police agencies have always conducted this "cat & mouse" game with criminals and adversaries, in order to avoid or deter bad behavior.

In the past, however, a nation would have had to spend months planning how to seed an agent, or insert a special forces strike team, into what would be an extremely dangerous, risky, and unstable environment in order to "get back at" someone like al-Quso, or else postpone or forego any retaliation at all (and the hoped-for deterrent effect that prompt retaliation might have on enemies of this sort). With "drones," a nation's capacity to reach out and kill someone in retaliation for their criminal activity is considerably enhanced, and thus the frequency and timeliness of the deterrent responses has increased (and so, I gather, have the accuracy and effectiveness of such missions, while simultaneously minimizing the risk either of unintended collateral damage or loss of lives).

Here is the only new moral or legal wrinkle we need to consider: that with the ease of relatively risk-free performance, comes the tendency to engage more readily in actions at the edge of the law—vigilante actions—which require careful procedural oversight. Also in the spring of 2012, the U.S. National Security Adviser, John Brennan, discussed the killing of an American citizen and Al-Qaeda operative, Anwar al-Awlaki, in a drone strike in the fall of 2011. He was at pains to point out that there is a detailed procedural process and oversight for carrying out such drone strikes, although, because the missions are classified, he was not at liberty to satisfy all questions from the media about the details of this procedure.

Of course we want careful procedural review and oversight of such missions and of the agents who carry them out, in lieu of the criminal trial such suspects would receive if apprehended in our own countries. We do not want the President or Prime Minister, his or her advisors, or senior intelligence or military personnel deciding arbitrarily which rogue citizens to execute without benefit of trial or due process in foreign settings, solely on their own recognizance. And, of course, they do not. Yes, there is a finite risk that troubling future precedent might be set; or that inappropriate or unauthorized actions might be undertaken, with serious legal and moral consequences. But this has always been the case, and the availability of remotely-piloted systems to aid in hunting down and targeting the suspects simply enhances our capacity to engage more effectively in these missions, while greatly reducing the risk of suffering harm while doing so to our own operatives.

The last point, in particular—that dramatic reduction in risk of harm to our human agents - whether special forces, covert operatives, or military combat personnel—is a good thing, not a bad thing. That is again the application of this "principle of unnecessary risk." The two gentlemen about whom I have spoken above, together with Osama bin Laden himself, were extremely dangerous and destructive persons, who had clearly warranted capital punishment for their crimes. But, of course, this condemnation and death sentence is a judgment which we should always reach with due care, thorough deliberation, sound judgment, and appropriate oversight. For myself, I am not sorry to say that I rest assured at present that our world is a better place, even if only incrementally, because Anwar al-Awlaki and Fahd al-Quso, and their friend Osama bin Laden, are no longer in it.

Autonomy and Lethality

Finally, let us consider whether introducing ever greater degrees of autonomy into such systems raises any new troubling ethical or legal questions. As a result of more careful consideration of remotely-controlled systems at present, we might now readily see that some new questions and challenges are raised in this context, but not as many as critics might think.

The most dramatic presentation of the moral and legal obstacles comes from the computer scientist and roboticist Noel Sharkey, who teaches robotics at the University of Sheffield in the U.K., and is a co-founder of ICRAC—the "International Committee for Robot Arms Control." ICRAC wants international laws that would outlaw the development, manufacture, and use of autonomous systems armed with lethal force. Sharkey is also a fierce critic of America's use of remotely-piloted drone strikes. I hope from what I have said up to this point, especially about due process, oversight, and troubling precedents, that one can surely see that his criticisms are not unreasonable. But I myself obviously think Sharkey and his colleagues are simply mistaken or confused regarding specific points of fact and procedure, as well as of morality and international law.

When it comes to autonomous lethal systems, these vociferous critics appear to envision something like, once again, the famous robot characters, R2D2 and C3PO from the movie *Star Wars*—– but now fully weaponized and roaming the mountains of southern Afghanistan entirely on their own recognizance, yet unable to distinguish between an enemy insurgent, a local shepherd, or a child playing with a toy rifle. The critics are probably correct to object to some of the features of that wildly-imaginative scenario, but we are nowhere even close to being able to operationalize such systems, nor do I think that is where we really want, in any case, to try to go.

Their opposition, however, places them squarely in the path of the apparent trajectory of engineering and weapons development in the U.S., in which the benefits of economies of scale (in a time of scarce personnel and financial resources), and of otherwise desirable force multiplication are being sought primarily by enhancing the degree of autonomy in our unmanned platforms. We should not lose sight of the fact, however, that enhanced autonomy is not the only way to achieve those goals. Improving the human-machine interface—replacing cluttered and clumsy, cobbled-together *Predator* control stations with a joystick or iPhone-like controller—would yield immediate dividends in economy, reliability, and force multiplication.[2] We need to keep open minds about the relative desirability of alternate engineering paths to the same policy objective, and not become captive of the intriguing, but also relentless and sometimes unreflective, single-minded drive toward full autonomy.

Another colleague, however, computer scientist and roboticist Ronald C. Arkin, advocates the path of enhanced autonomy for a surprising reason: he thinks that introducing ever-greater degrees of autonomy into lethally-armed unmanned systems will not only reduce risk to our war-fighters, but eliminate the possibility of errors, mistakes, and even intentional war crimes that human combatants sometimes make or commit, because robots do not get scared, get angry, or try to get even. They do what they are told. Providing we take due care to ensure their safety and reliability (a tall order for defense industries, in particular), then robots, which literally have "no skin in the game" and no interests and concerns of their own, will be more reliable and effective in conforming to the moral rules and international laws of armed conflict than their human counterparts.[3] And if so, that is a good thing, and we are not merely permitted, but obligated, to develop such systems just as soon as we safely and reliably can.

That, at least, is Professor Arkin's argument. Readers may have seen his work in the *Proceedings of the IEEE*. For my part, I've expressed caution primarily about marrying "strong AI" with full lethality. I do not want robots, at least at present, capable of altering their mission or making lethal targeting decisions entirely on their own, without some supervision. For example, I would be uncomfortable having my lethally-armed iRobot "Roomba" (a simple vacuum-cleaning robot) deciding to shoot an intruder late at night that it judged to be breaking a window to get into my house, when in fact it was me, quite drunk, and having forgot my house keys. Again, we are far from that point, but I do not think a great deal is to be gained by trying to get there.

Instead, especially as with our marine underwater unmanned systems at present, I'm comfortable with some degree of force being coupled with evasive tactics under carefully scripted conditions. Sentry robots in a demilitarized zone, or on a heavily-guarded security border over which transition is absolutely prohibited, might be permissible. The same would be true for a swarm of lethally-armed "Fire Scouts" (small robotic helicopters) guarding the "no-go security zone" around a naval fleet or carrier group. Those are what I mean by "highly scripted" environments, in which mission and targeting objectives are carefully circumscribed within fully programmable boundary conditions.

The marine underwater environment, in particular, is an ideal environment for scripted lethal autonomous missions. We do not normally get a lot of commercial or civilian traffic down there, for one thing, apart maybe from James Cameron diving into the Mariana trench, or Jacques Cousteau's research group. And of course, the whales! Provided we took due care, again, to avoid such circumstances, the most likely encounters below the surface are with criminals (drug runners or terrorists operating partially submersible vehicles and engaged in what our British allies would call "mischief"), as well as with enemies, and adversaries. So the opportunity for unintended collateral damage is reduced nearly to zero by the initial conditions. My own engineering colleagues at the Naval Postgraduate School are working on such systems, which include enough executive oversight by humans in the loop to ensure that their performance, including targeting and destruction, when called for, would be morally reliable and wholly in conformance with applicable international law. Again, and finally, I find this to be both a legal and morally acceptable application of engineering expertise in the field of unmanned systems.

Notes

1. Bradley J. Strawser, “Moral Predators,” in G.R. Lucas, ed, *New Warriors/New Weapons: Ethics and Emerging Military Technologies, Journal of Military Ethics 9,* No. 4 (December 2010).

2. Professor Mary “Missy” Cummings, USN (retired), a systems engineer in the HAL Laboratory at MIT and project supervisor at ONR, has championed this alternative.

3. G.R. Lucas, Jr, “Engineering, Ethics, and Industry: the Moral Challenges of Lethally-Armed Autonomous Systems,” in *Killing by Remote Control,* edited by Bradley J. Strawser (Oxford, 2012), chapter 11.

Chapter 13
Ethics and Techniques of the Invisible: Ethical Aspects of the Use of Undetectable Robots in the Private Sphere and Their Extension to Military Robots
by Dominique Vermersch

"Le propre de la volonté, c'est précisément d'être un pouvoir totalement inobjectivable" ("The peculiar end of the will is to be a wholly inobjectifiable power")

—Jean Ladrière[1]

Introduction

As a researcher and teacher at a national school of agronomy, I feel somewhat of a stranger to and probably unworthy of speaking in this noble hall. Somewhat of a stranger then but not a moral stranger or a moral alien as defined, for example, by T. Engelhardt; because we all have, I believe, the conviction of sharing, to however small a degree, the same conception of the good.[2] This is precisely what is demonstrated by the task of dialogue, cooperation, and objectivation that has brought us together today.

The topic suggested to me is as follows. Amongst other attributes or properties that one would wish to bestow on robots, invisibility and even "undetectability" are probably amongst the most prized. This is true both in the military sphere and in the civil and private sphere with, especially, the possibility of putting individuals and societies under increasing levels of insidious surveillance. In both cases, these attributes are deployed in our relationships with others: be it with the aim of protecting them, watching over them, incapacitating them or killing them. In this way, they depend, in part, on strictly human characteristics and performances, limited by nature, and that it would therefore be proper to exceed to achieve the results that we have just mentioned.

We are proposing here to contribute to laying down the boundaries for the ethical impact associated with achieving such properties and putting them to effective use. In this connection, let us note that robotics is not alone in trying to achieve these properties. The invisible and the undetectable logically take us to the need for scale; at the observation and action level, that falls precisely within the objectives of nanotechnology. The affiliation between robotics and nanotechnology should also help us to clarify the ethical questioning that is the purpose of this presentation.

This will only be an outline today, intended to be descriptive rather than prescriptive, covering only the issues of the invisible and the undetectable.

Between Robotics and Nanotechnologies, Common Characteristics

To improve our understanding both of the ins and outs of robot development and the ethical impact inherent to their use, it would seem expedient to discuss, as a background issue, the advent of nanotechnologies. Let us first of all identify several characteristics common to robotics and nanotechnologies that are capable of providing them with the desired attributes of invisibility and undetectability.

A Relevant Scale

By the henceforth possible exploration and manipulation of matter at the atomic scale, the nanotechnologies are aiming no more and no less at *"building the world atom by atom"* or rather at rebuilding it, including the human race. The exciting aspect of the adventure combines in fact straight away with the imaginary and fantasy, as no area of activity is meant to escape these supposedly generic technologies: sciences and technologies including the human and social sciences, health, agriculture, food, industry, army. Thus, and as with robotics, there is no assigned territory; the prospect is one of *"functionalizing" matter or of programming artefacts or synthetic organisms.*[4] The nanometric scale is also probably the most relevant if we are seeking to build invisible, undetectable robots. This is confirmed by the five successive waves announced for the nanotechnologies:

1. Pursuit of miniaturization of electronics down to molecular components.
2. Invention of materials with "thrilling" properties.
3. Invention of responsive products capable of changing state in accordance with their use and environment: programmable matter.
4. Assemblages of nanosystems or nanorobots (mechanical, hydraulic, optical, etc.).
5. Nanosystems with the ability to self-build and replicate.[5]

Improving Human Performance

Nanotechnologies should contribute to the process of convergence then fusion with biotechnologies, information technologies, and the cognitive sciences (NBIC), in preparation of a "unified cause-and-effect understanding of the physical world from the nanoscale to the planetary scale."[6] This forecast convergence will set itself an objective which accords with that assigned to robots: namely, the augmentation of human performance. The goal is therefore one of effectiveness which, like any such goal, is never axiologically (i.e. morally) neutral.

Science, Fiction, Science Fiction?

A double language often prevails in the presentation of the advances in robotics and nanotechnologies. By closely mixing science and fiction in the presentation of their advances, robotics and the nanosciences maintain a sort of common rapport with the public, ultimately promoting disquiet about the former. At the same time though, there is an insistence on the argument of continuity: the advent of robots and of the nanotechnologies forms part of a technological, biosynthetic or even biological continuum.

This arises upstream from a blurring of the frontiers between sciences and technologies, between nature and artefact, between inert and living, between man and robot, between subject and object, between matter and spirit. This lack of differentiation looks for support to the digitization of the world and the bringing together of bits, atoms, neurons and genes. *In fine,* a lack of differentiation that is precisely the breeding ground of the invisible and the undetectable.

Robo- or Nano-Surveillance?

Surveillance is one of the first functions assigned to robots when they enter the scene in military conflicts; and it is perhaps in this area that the convergence between robotics and nanotechnologies could be the most conclusive.[7] In fact, when we say surveillance, we mean the capture, cross-referencing, processing and storage of information based on nomadic, invisible, or even undetectable devices. It is also in the civil and private sphere that nanoelectronics leads to spectacular, not to say terrifying effectiveness; and this could have military effects that render the first generations of robots obsolete. Already in widespread use in large supermarkets, in biometric passports, which have been compulsory for farm animals since January 2008 for health reasons, "RFID" chips can also be implanted in the human body.[8] This "electronic tattoo," to adopt Dorothée Benoit Browaeys' phrase, was authorized by the American government in 2004 for medical and security monitoring in particular.[9] Like livestock, the complete traceability of humankind would therefore be possible. As exchanges between people increasingly rely on electronic media, these exchanges always and in all places leave traces that can be sequenced, recorded, cross-referenced, and profiled using "ubiquitous computing." The latter terms was coined by Mark Weiser, the director of the Xerox Research Centre at Palo Alto, to refer to the thousands upon thousands of networked, integrated, and distributed processing devices. We could now talk of a true economic war to take over databases and the corresponding network architectures. An assumption of control to which the Google company is no stranger.

By extending the trends, one can imagine the potential military impact of this vast enterprise of digitization and storage of every human act and gesture. We shall offer only three outlines. Whoever holds information or all of the information prior to any hostile act obviously has a decisive advantage, and this probably unbeknownst to the opposing party. Will we not also be capable of producing "killer" signals received by RFID chips implanted in the human body? Let us note that, on various websites, this type of phantasmal threat was suggested at the time of the H1N1 flu epidemic: namely that the vaccine used also deliberately contained dormant but potentially fatal viruses. And finally rather than build robots that are a pale reflection of humans, is it not more valuable to adapt humans to robots, by inserting transponder implants that incite them to do as Big Brother says?

Beyond Anthropomorphism

Anthropomorphic projection would therefore become a "robomorphic" reduction. This can be observed, by analogy, in the argument of the animal rights cause in favor of an ontological non-difference between man and animal, where the anthropomorphic projection is coupled with a zoomorphic reduction: "voir un animal quand nous nous regardons et voir un humain quand nous regardons l'animal" (seeing an animal when we look at ourselves and seeing a human when we look at the animal).[10]

Whether discussing robotics or nanotechnologies, more than ever it is the living that is imitated, in its structures and in its organization: it is a question of designing "bio-inspired" materials, objects and automata whose evolution we could now control and even re-direct. All this will make the powerful anthropomorphism that still characterizes robotics obsolete. We will be entering the era of synthetic biology: rather than copying and improving man and his faculties, it would be more interesting to modify and replicate other organisms (bacteria, viruses) that are "much more" invisible and/or undetectable, including for military ends. In summary, assuming that the promises offered by the nanotechnologies might sooner or later enter the realms of possibility, will the current development of robotics, especially military, not be encumbered by a congenital anthropomorphism that is of little use? Is man the correct model to reproduce?

For a Broadening of the Ethical Question

The ethical questioning pertaining to the techno-sciences is broadly impregnated with utilitarianism and too often reduced to comparative analysis of the risks/benefits of the innovations that they provide. On the risk side, the focus is placed on the allocation of the liabilities incurred. It is necessary therefore to broaden this ethical questioning, especially as innovations are informed by anthropological conceptions and feed back into the latter.

The Incompleteness of Embedded Ethics

For some writers, such as Ron Arkin the military use of robots would offer a certain number of ethical benefits, but these in fact only occur in the technical area.[11] By way of illustration, the software loaded into the robot could actually include an ethical module that has a complete set of the conventions, rights and duties relevant to a just war. Also, the robot has neither emotion nor feelings (anxiety, fear, etc.). All temporary states that can cause interference with the moral conduct of the human soldier. The robot could therefore be used as a prosthesis, even in existential and moral behaviour.

However, this last argument is reversible, in the sense that according to the time step allocated, emotions and feelings can contribute to marking out or even optimizing the moral conduct to follow. Also, like in a game of chess, it is impossible to define an optimum strategy for the "war game." In other words, ethics cannot dissolve into legal formalism or, in consequence, into technical functionality. Military casuistry cannot be captured and established using a logical tree-structure or a computer program, especially when there is a need for proportionality or even moral probabilism. It seems to me, moreover, that this counter-argument is also raised in Professor Lucas' contribution. This does not mean, however that there is no appeal against the sentence: while it may not be able to be a substitute, the technology of robotics may facilitate proper moral conduct.

Autonomization of Technology Versus Moral Autonomy

> "Technology has become a biological process which, as such, is removed from man's control"
>
> —Werner Heisenberg[12]

The advent of robots is an emblematic illustration of the autonomization of technology that seems to challenge head-on the modern demand of the subject for moral autonomy: which of these two autonomies will have the final word? Today, is man's ability to self-limit his technological power not called upon to become the best testimony to the affirmation and durability of his moral autonomy?

Nature— an Obsolete Moral Bastion?

All physics, as a representation of nature, is hiding metaphysics in its baggage.[13] Every science and its technical applications carry and suggest an ethics of substitution. This is what we observe, for example, in the animal kingdom where the scientific theory of evolution lends itself to a philosophy, indeed, to an ethos of adaptive selection.

As a scientific and technical innovation, the question now is to know what metaphysics the possibility of invisible, undetectable robots conveys. And it is in this self-same perspective that Jean-Michel Besnier notes that the imaginings produced by scientific and technical innovations today feed substitute ideologies for traditional humanism: a post-humanism or even a trans-humanism convinced of the obsolescence of the boundary between man, animal and machine, on which humanism rested.[14] In other words, in such a world, the very word "ethics" and its humanizing intent, simply no longer make any sense.

Human Irreducibility and Excessive Violence

These various suggestions for broadening the ethical question call into question, in one way or another, human irreducibility. The working hypothesis that we should like to propose is that this calling into question generates excessive violence in response. Is this not what we are seeing in the extreme difficulty of introducing a public debate on nanotechnologies?

Ethical Antics

It is important therefore for ethical questioning not to allow itself to be wholly subordinated to the technical register. If there must be ethics, they cannot just be subordinate to the technology, as a sort of appendix to the instruction manual. Such an inverted tropism of the relationship between technology and ethics is in fact as old as the world and has been recorded in the major works of wisdom and even in cosmogonic stories.

What, for example, does the Bible tell us in Genesis? That in contemplating Creation, it is given to us to contemplate the Creator and his loving design on the world. Thus, and without sharing the believer's religious convictions, the first act of contemplating nature allows us to deduce and reason a prior ethical meaning, capable of suggesting a form of action for the transformation of the world. *In fine,* ethics precedes technology. As Fabrice Hadjadj has so shrewdly remarked, as Genesis evokes the creation of the Garden, it invites us to a contemplation preceding action: "And out of the ground made the LORD God to grow every tree that is pleasant to the sight, and good for food" (Gen 2, 9).[15] The respectful entry to knowledge of nature, a given nature, is precisely the pleasing moment, the moment of beauty. And what is beautiful takes us back to what is good; what is good to do in, by and with nature. Beauty tells us something about what is good. That is to say, metaphysically speaking, that the transcendentals are communicating with each other.

Still, the first flowering of modernity will be marked by the eviction of this prior contemplation, which will contribute to a gradual confusing of knowledge with power, making them indivisible.[16] This "production of power" will be put into effect with increasing returns to scale. In other words, an increase in knowledge will lead to a more than proportional increase in power. It is a case here of the power of the technology that will bring progress; a technological progress that feeds a conviction that is still deeply rooted: that this technological progress results in an advance in humanity. This conviction is such that nothing appears capable of limiting technological progress: "what can be done will be done." Due to our technical power over nature new possibilities open up, man anxiously senses the need to self-limit this power, but without managing to do so freely. More generally, it is this autonomization of technology that challenges head-on the modern demand of the subject on moral autonomy: of these two autonomies, which will have the last word?

Technology is also the object of an act of faith: it has replaced the traditional religions. What we asked of God in the past—health, healing, happiness—today we ask of technology. Our search for perfection no longer focuses on ourselves but on the results of technology. If there must be ethics, perhaps it is only subordinated to technology. This inversion resembles a sort of moral aping, where evil takes on all of the appearances of the good. And it is precisely this very inversion that Fabrice Hadjadj recalls at the moment when Eve prepares to eat the forbidden fruit: "And when the woman saw, that the tree was good for food, and that it was pleasant to the eyes, and a tree to be desired to make one wise" (Gen 3, 6). *Good for food and pleasant to the eyes:* it is as if man's original fall is inaugurated by this inversion of action and contemplation, an inversion which shapes desire and gives access to discernment, in other words precisely to ethics. The latter would be a derivative, a by-product of the technology and therefore of the multitude of human desires; such is the case with moral pragmatism which can be resumed in the following phrase: "it works, so it's fine." One might believe, therefore, that contemporary ethics would ultimately be an even more formidable device than technology itself.

Ethics as a Peculiarity of Human Action

As human action, ethics supposes and consolidates an authentic freedom; it presupposes therefore a certain imprecision of nature and of the world.[17] In this sense too, human action cannot be reduced to a pure and simple determinism, to a simple causal relationship governed by necessity alone. By causal relationship we understand here the linking of a "cause" phenomenon which precedes in time an "effect" phenomenon; we find many such in nature. In human action, there also exists a logical relationship, in other words a rational link between the motives, intentions, and objectives of the action, a link which allows the passage from an initial state of nature to another state of nature different to that produced merely by the causal relationships based on the initial state. Human action thus begins with the possibility of a bifurcation, in other words a state of nature leaves it wide open to new imprecisions. Now, what do the new technological opportunities produce, if not new and increasingly numerous bifurcations in the face of which the ethical choice, and therefore human freedom, are called upon to make a pronouncement?

Now it is precisely faced with a bifurcation, an imprecision, that the feeling of responsibility, the requirement to answer for something to someone emerges, with nature acting here as a mediator. The human being has this feeling because he is a being who is divided within between what he is and what he is called upon to be; he maintains an interface between the being of the present and the being to come. Human action is located precisely between these two components of being, with the aim of gradually, freely, and rationally overcoming the distance that separates them. Ethical questioning, the ethical orientations given to our acts, the standards that we accept contribute thus to qualify and to bring forth "the humanity of man;" to bring forth, differentiate and comply with all that there is "human in man." Now the human is first of all existence, human existence which is characterized especially by this movement between "the being" and the "must be," or rather by the need borne by "the being," *of the need that inhabits existence.* Such is the auto-constitutive task of existence.

It is precisely by abstaining from the moral use of reason that philosophical modernity has reduced this "call to be" to a "must be," in other words to a set of moral injunctions stripped of their teleological underpinning and which, according to Alasdair MacIntyre, sooner or later become inaudible and incomprehensible.[18] To this end, the American philosopher recalls that Aristotle, followed in this by the monotheistic beliefs, had developed a system characterized by a fundamental distinction between *man as he is* and *man as he could be if he realized his essential nature.* Ethics was then the science that should have allowed the passage from *what I am to what I could be;* it assumed therefore a conception of man as a rational animal capable of grasping its end (happiness) and of achieving it. It is the thirst for happiness inscribed in human nature that invites reason to bring order to human desires by prescribing moral habits (virtues) and by proscribing vices. This moral use of reason is supported by nature, insofar as it is there that resides good in the form of ends whose deployment will require the free collaboration of man.

To rehabilitate the moral use of reason is therefore to find a synthetic encounter between freedom and nature, far from any creationist vision of the latter. This moral use therefore spurs on the scientific effort to update the evolutionary trends inherent in nature; and, to take up Ladrière's phrase to "leur donner un sens en les réinscrivant en [nos] propres initiatives" ("to give them meaning by making them a part of our own initiatives"). The challenge today is more than critical!

Notes

1. Jean Ladrière *L'éthique dans l'univers de la rationalité (Ethics in a World of Rationality).* (Artel-Fides, 1997), chapter 12.

2. "Le problème éthique, tel que le définit par exemple T. Engelhardt, est de parvenir à un accord entre 'étrangers moraux', i.e. entre personnes qui ne partagent pas une même conception du Bien (de ce qui est intrinsèquement bon, ou avantageux, ou utile, ou préférable)" ("The ethical issue, as defined by T.Engelhardt, for example, is to arrive at an agreement between moral aliens, i.e., between people who do not share the same conception of the Good—of what is intrinsically good or useful) in Paul Clavier, *Qu'est-ce que le bien?* (What is Good?) (Vrin, 2010), 15

3. Title of the brochure published by the National NanoInitiative launched in 2000 by President Clinton: *Shaping the World Atom by Atom.*

4. Dorothée Benoit Browaeys, *Promesses et craintes des nanotechnologies* (Promises and Fears of Nanotechnologies) Etudes Tome 412 No. 3, 2010, 319-330.

5. Dorothée Benoit Browaeys, *Promesses et craintes des nanotechnologies.*

6. Mihaïl Roco and William Bainbridge (Eds.), *Converging Technologies for Improving Human Performance: Nanotechnology, Biotechnology, Information Technology, and Cognitive Sciences* (Dordrecht, 2003) Executive summary, x. http://www.wtec.org/ConvergingTechnologies/Report/NBIC_report.pdf, (accessed 18 October 2013).

7. The information in this paragraph is taken from Dorothée Benoit Browaeys, *Promesses et craintes des nanotechnologies.*

8. RFID = Radio Frequency Identification labels.

9. Dorothée Benoit Browaeys, *Promesses et craintes des nanotechnologies,* 325.

10. Jean Marie Meyer and Patrice de Plunkett, *Nous sommes des animaux mais on n'est pas des bêtes.* (Paris, 2007).S

11. Ronald C. Arkin, "Ethical Robots in Warfare" *IEEE Technology and Society Magazine* vol. 28, no. 1, 2009. 30-33. http://www.cc.gatech.edu/ai/robot-lab/online-publications/arkin-rev.pdf, (accessed 18 October 2013).

12. Werner Heisenberg, Role of Technology in Man's Relationship with Nature, *The Physicist's Conceeption of Nature* (1958). http://www.wisdomportal.com/Technology/Heisenberg-Nature.html, (accessed 22 October 2013).

13. From the Greek term *physis,* which the Romans translated precisely as *natura.*

14. Jean-Michel Besnier, "Post-humanisme et Trans-humanisme" (Post-Humanism and Trans-Humanism) in COMEPRA, Activity report, November 2004-December 2006, (2007), 41-44.

15. Fabrice Hadjadj, *La foi des démons ou l'athéisme dépassé* (Paris, 2009), 118.

16. "Knowledge is power," according to Francis Bacon's phrase.

17. This last section relies largely on chapter 12 of Jean Ladrière, *L'éthique dans l'univers de la rationalité* (Namur, 1997).

18. Alasdair MacIntyre, *Après la vertu,* (Paris, 1997).

Chapter 14
Preparing Military Leader Education for the Age of Robotics
by Eugene K. Ressler & Barry L. Shoop

Introduction

The contribution of this paper is a framework for reasoning about the impact of military robots over the next several decades with the purpose of shaping the education of military leaders right now. What that shape should be is discussed only a little. Our main goal is developing a view of the entire problem. This is surprisingly difficult, not least because it requires predicting an uncertain future—a risky but necessary enterprise.

The stakes are high. Going to war has been mankind's costliest endeavor. The calculation of when and how to go to war has been the ultimate testing ground for theories of politics, diplomacy, grand strategy, military doctrine, and economics—the thought disciplines that nations apply to understand and govern relationships with each other, their societies, and even between mankind and the natural world. *Robots have very strong potential to fundamentally alter this crucial calculation.* Military leaders being educated today will deal with the results during their lifetimes, successfully or not. The traditional thought disciplines will be challenged. Leaders must be prepared to use them as far as possible and then discard them, reverting to first principles as necessary to make right decisions. If there is error in their preparation, it had better be on the side of caution. There is surely a risk of "crying wolf"—predicting a revolution that never occurs. So be it. The reverse—no preparation or uneven preparation among nations, while a tidal wave of robot-induced change mounts unseen—is much worse.

We will find strong evidence that fundamental changes in the nature and conduct of war are already resulting from the proliferation of robots in military forces, with much more to come. Education must respond. For professional educators, this pattern is no surprise. Toffler (Toffler 1970) and others warned four decades ago that that the role of education was shifting from one of imparting knowledge about the world to imparting the ability to gain knowledge and adapt to a rapidly changing world throughout a lifetime. This has come to pass, particularly in the area of technology. In the authors early life, vacuum tubes and 5-minute recordings on vinyl disks were state-of-the-art. Now they are quaint. Change has accelerated vastly since then. The irrelevance of vacuum tube knowledge in a microcircuit world must pale when comparing the technology of today with that of 2050.

What does this mean for educators? Nothing essentially new. The constraints of human learning remain the same. Order-of-magnitude change in complexity and priority will, however, rule our days. The work of educators has always been first to envision the future world and then, with vision in hand, provide experiences to students with a lofty goal in mind: enable their positive effectiveness in that envisioned future. This burden was lighter when change was moderate. Through most of history, careful observation of the current world and commonsense extrapolation by individuals and small groups were sufficient. We have a word for the result: wisdom. Imparting personal wisdom has been the purpose of educators from Plato until the middle of the twentieth century. This is no longer true. At least, it is no longer the whole story. Envisioning the future and planning for it has graduated to an organizational function at the highest level in most schools, required for many forms of accreditation. For providing the right experiences to students, the wisdom of individuals has been supplemented with formal analysis and design processes. Educators of military leaders are in exactly the same boat. They envision future warfare and their students' roles: leading soldiers and units to prepare and fight. They create educational experiences to match these challenges.

Robotics Revolution?

The Introduction was the foundation for a question to guide the rest of this work. Let us ask it:

Should educators of future military leaders be preparing current students for rapid future change due to robots? If so, how?

The rest of the paper provides an answer. "Revolution" is the best term for significant, rapid change. Therefore, we begin with the simpler question: *Will there be a military robotics revolution?* Revolutions make news. Therefore the first step is to examine recent events for signs that big changes are afoot.

We need not look farther than current conflicts. Operational needs in Iraq and Afghanistan created requirements for large numbers of robots and unmanned vehicles. New technologies created in response mitigated some of the riskiest battlefield situations on the ground. Robots served as "point men," moving into closed spaces possibly occupied by armed enemies. They remotely sensed explosive devices and performed the delicate tasks needed to neutralize them while their human operators stood safely out of harm's way. Robot Unmanned Aerial Vehicles (UAVs) entirely changed cost/benefit ratios for obtaining military intelligence. They proved cheaper than space-based platforms and much more flexible. By removing human operators entirely from the battlefield, they eliminated risk of pilot prisoners of war and the associated political and operational costs. Their ability to loiter, observing any chosen objective for long periods, with sensors more potent than human eyes, provided commanders a new level of awareness. Armed UAVs provided new stand-off precision strike capability, also with less operational and political risk than ever before.

Just as the first Gulf War saw US forces overwhelm Saddam Hussein's Army, sparking a rethinking of military strategy in the mid 90s, today's decision makers worldwide have watched unmanned system advances and realized that a major military capability is being born. Programs to build more and more sophisticated robots have proliferated. In 2000, the US military possessed less than 50 UAVs and 162 ground robots. By 2010 these numbers had grown to 7,000 and 3,600 respectively. Some 311 different US systems are in use or in development. UAVs have flown 500,000 hours and ground robots have completed 30,000 missions, detecting or neutralizing 15,000 explosive devices. At least 60 countries either possess or are acquiring significant robotics technology. (Weiss 2011) A $8 billion (€5.7 billion) annual US market is projected by 2016. (ABI Research 2011) The US Congress in its Defense Authorization Act of 2001, mandated goals that by 2010, one-third of all strike aircraft and by 2014, the same fraction of military ground vehicles should be unmanned. The Department of Defense subsequently published its Unmanned Systems Integrated

Roadmap for Fiscal Years 2009 through 2034 (Clapper, et al. 2009). Every major US Defense research and development (R&D) organization has a major program to develop robotics of some form.

From this list of contemporary developments, we conclude that national, military, and business leaders are convinced military robots are worthy of attention and investment. These two factors are mutually reinforcing. Investment begs more attention from the science and engineering community. Developments accelerate. New developments motivate new requirements from Defense and concomitant new investment. This cycle is important. In fact, we will exploit the process that governs it for our purposes—gaining insights on leader education.

Three Models That Fit

Though the cycle itself is a necessary condition for technological revolution, it alone is not sufficient. New technologies are adopted routinely by militaries worldwide. We must turn elsewhere for ideas on when a normal level of change crosses the threshold of revolution.

Three disciplines of thought and their associated communities offer relevant viewpoints. Most obvious is military science. This community is already concerned with the theory and practice of robot employment: logistics, tactics, operational art, and strategy to bring about maximum positive effect on battlefields. A second is scientific and technological development. The science and engineering communities organize mankind's intellectual effort to understand nature and use this understanding to create and refine technologies. Robots are perhaps the ultimate expression of science and engineering art. Last is the viewpoint of the marketplace. Defense industries respond to supply and demand forces, albeit distorted by non-market influences of government. Increasingly, technology demands of average citizens lead markets to allocate enormous resources to technology development and manufacturing. These can far exceed what even a rich nation can devote to military technology development. The result has been steadily increasing "Off-The-Shelf" acquisition of commercial technology either for direct use or adaptation to military purposes. Indeed, civilian commercial market forces could have an equal or greater effect on military robot development than those generated by governments. Industry—defense and commercial—will have much to say about the robotic future.

Revolution in Military Affairs

Each of the three disciplines has at least one strong model of revolution applicable to the case of robotics. In military science, a theory of Revolution in Military Affairs (RMA) due to technology has been in development since the early 1990s. (Metz and Kievit 1995) It hypothesizes that advances in sensing, particularly from space platforms, communications, information processing, and stand-off precision strike (a reference primarily to cruise missiles) have provided fundamentally new mechanisms to see, understand, and affect adversaries and to command battlefield events.

The RMA meshes with a theory of strategic and operational command known as the OODA Loop: Observe, Orient, Decide, Act, due to Colonel John Boyd (Osinga 2007). The OODA loop describes military victory and defeat in terms of decision cycles. The winning commander is the one who accurately *observes* unfolding events on the battlefield, *orients* herself so that evaluation and analysis of events are aligned with reality, rapidly *decides* and promulgates decision on the best course of action, and follows through with necessary direction and support for *action*. Moreover, she does all this faster and better than her adversary, while exploiting insight and intelligence on the adversary's OODA loop to confuse and disrupt all four stages of his cycle.

When the technology available in 2000 is placed logically on the OODA loop, strong support for the Orient and Decide phases of the cycle is evident as shown in the figure. Additionally, space-based sensing enhances the Observe phase. These drove RMA in its beginnings.

The argument for a robotics revolution is that this early suite of technologies was incomplete. It failed to support the decisive Act phase of the OODA loop, and it offered more than it delivered in the Observe phase. Notorious misreadings of satellite reconnaissance have occurred (United Nations 2003) with some regularity.

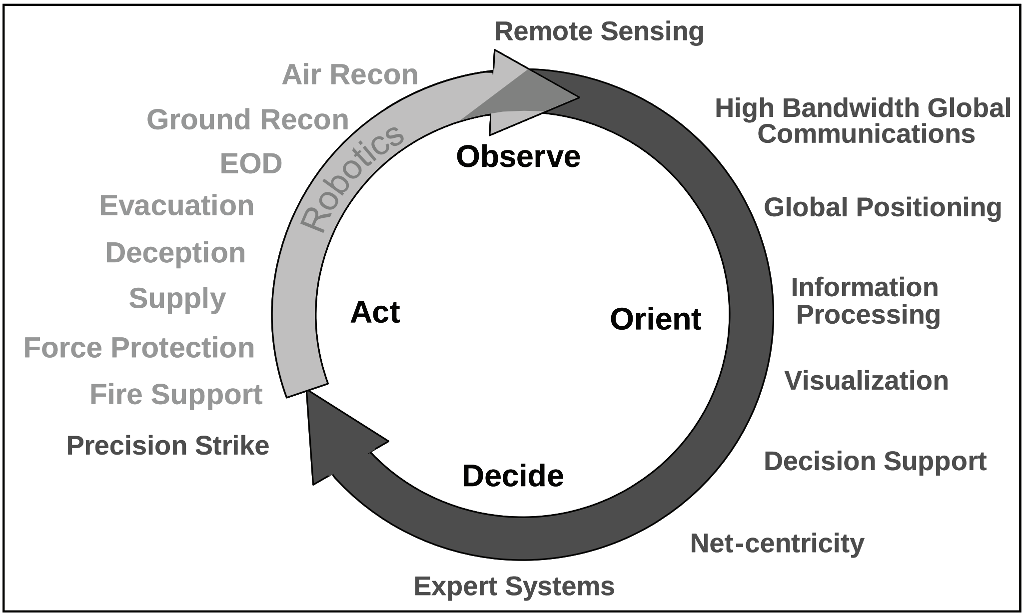

Figure 7. OODA Loop.

Source: Created by Author.

Military robots already fill the gaps, extending support that RMA technologies provide to all OODA loop phases. How complete will the gap-filling be? Unmanned systems for logistics, rescue, fire support, "close in" reconnaissance of many forms, and other selected applications (Clapper, et al. 2009) will soon provide commanders with important new capabilities at little or no risk to soldiers. In this manner, the shift in cost/benefit already seen with reconnaissance and stand-off strike by UAVs has potential to extend to every major battlefield activity. US national policy has already been enabled in the form of armed UAV interventions in Pakistan. Such a level of change easily qualifies as revolution under the RMA umbrella.

Scientific Paradigm Shift

Turn now to science and technology. Stephen Kuhn in his classic work (Kuhn 1962) developed a comprehensive model to describe the historical progress of science. He distinguishes *normal science* from periods of revolutionary *paradigm shift*. Normal science is evolutionary. A collection of scientific theories and practices grows up within a community of devoted people—a paradigm. A successful paradigm provides a support system for generating more success: new scientific discoveries. It provides methods and a structure—a subculture—that inspires scientists to invest their life efforts because it eases access to established knowledge, productive collaboration, financial resources, and other advantages.

Kuhn argues that paradigms gradually wear out. New findings conflict with standing theories, or the accepted methods of the paradigm are exhausted: refined to the limit of their ability to elicit new knowledge. In time, an entirely new paradigm must emerge to compete with the failing one and replace it. This is often the work of younger community members. The competition can be acrimonious. A revolutionary shift to the new paradigm follows.

Kuhn's model is restricted to basic science: learning truths of nature by applying the scientific method. Military science, however, is not a basic science. Herbert Simon (Simon 1996) provides the necessary link in his concept of sciences of the artificial. He argues that the behaviors of complex systems need not be understood from the inside, out—from detailed to macroscopic views. Rather, he advocates gaining useful knowledge by empirical study of external behavior and designing models of the behaviors rather than the systems themselves. Simon's goal is an approach to artificial intelligence, but his notion of applying the scientific method—experiment and measurement—to direct design of complex systems has been used as a methodological philosophy in other disciplines including political science, psychology, and system-of-systems engineering. Our present purpose is an invitation to extend this to military affairs.

Are military robots a Kuhn-style paradigm shift in military science? Many events and decisions discussed in the previous section are convincing indicators. A community of scientists and engineers—with substantial resources available—is quickly creating a methodology of military robot development with standard design considerations, tools, and techniques. Military policy and doctrine developers are also gelling as a community with a literature (Headquarters, Department of the Army 2010). Not least, there are examples of "old paradigm" resistance to the new. In 2008, Secretary of Defense William Gates publicly chastised his Air Force for moving slowly to increase UAV capability in active theaters of war (Weinberger 2008). Later forced resignations of the Air Force Secretary and Chief of Staff, linked partially to this issue, were historically unique (Air Force Times staff 2008).

Market Disruption

Clayton Christensen (C. M. Christensen 1997) performed a large empirical study of business failures to develop a model of *disruptive technology*—an excellent "science of the artificial" application. He depicts a free market as a collection of relatively independent *value networks*. A value network is a system of R&D, suppliers, producers, and customers all organized to provide a product. Christensen describes value networks for disk drives, excavators, land transportation, etc. Each value network is an ecosystem for its product. Prices, margins, production quantities, marketing efforts, R&D investments, and organizational structures are set with respect to other parts of the network.

A disruption occurs when R&D within the value network of a relatively cheap, low margin, low-performing product gradually makes it good enough to do the job of a more expensive, high margin product. The personal computer (PC) was initially dismissed by minicomputer manufacturers. Within ten years, PC technology had become good enough to replace the much more expensive minicomputers in nearly all applications. Minicomputer manufacturers either shut down or entered entirely different businesses. This pattern is characteristic of disruption. Customers for an expensive product switch quickly to a cheaper one that has, through normal R&D, grown to be "good enough." The expensive product's value network is unable to adapt to the new, low cost margins. It simply dies.

Will robots be disruptive? Clayton Christensen himself cited UAVs as a disruptor with respect to much more expensive, traditional manned aircraft (C. Christensen 2011). Early UAV technology emerged from the model airplane market. It is not hard to envision other commercial technology value networks shifting sideways to disrupt traditional military R&D: industrial assembly line robots, sensors, intelligent controls, power, and drive systems.

Another likelihood is disruption within military R&D rather than from without. The Defense Advanced Research Projects Agency exists to find high potential disruptive technologies with military applications. The DARPA grand challenge pitted top robotics researchers against demanding cross-country and urban autonomous navigation problems (Thrun, et al. 2006). The Google Car (Markoff 2010) is a transplanted DARPA-sponsored technology development with high potential for future disruption.

Summary, Counter-Argument, Next Step

To summarize, our quick examination shows enormous attention and investments in military robotics already occurring, with plans for continued growth over the next two decades and more. Deeper analysis of predictable progress in robot technology with respect to models of military affairs, science, and market disruption is likely to further strengthen the argument for revolution in each case.

What are the arguments against? What could prevent a robotics revolution? There are no strong answers. Physics and the limits of engineering knowledge present the main hurdles:

1. *Efficiency of power sources:* Batteries, generators, fuels cells, solar, and other available energy storage and conversion technologies are currently inadequate for many robotics purposes—a severe limitation.

Progress has been steady if not dramatic. In 1980, electric aircraft were engineering novelties. Now they are a primary form factor of UAVs. Still, the ten-fold improvement in power-to-weight is dwarfed by the 1,000,000-fold increase in transistors per micro-chip that occurred in the same period. Power sources are a laggard among robotics-enabling sub-technologies.

2. *Bandwidth:* Nature places unbreakable limits on information flow, particularly the high fidelity wireless communication that robots frequently require. We are far from reaching these limits. Engineers are making the most of nature's offerings. Home satellite TV receivers, cell phones, Global Positioning, wireless baby monitors, and a hundred other bandwidth-intensive devices in our daily lives are all products of the last 30 years. Nonetheless, the unbreachable bandwidth wall must be considered.

3. *Autonomy:* Somewhere between the current state, where robots rely on detailed instructions from people, and futurist predictions of a "singularity," where mankind uploads itself to a global super-network, and human evolution continues by other means (Zorpette 2008), lies what machine autonomy will actually be during the lives of leaders being educated today. Many robot applications benefit from autonomy—machines emulating human thought. Though imagination has outstripped real progress in this area, the oft-lamented failure of artificial intelligence (AI) is a red herring, masking solid accomplishments. The "failure" rubric stemmed from a period where researchers focused too exclusively on symbolic abstraction (Brooks 1990) and in the definition of AI itself. The practical definition of AI is "human behaviors too complicated for current systems to emulate." Consequently, it is a truism that successful AI is no longer AI; it quickly becomes "normal technology." Modern expert systems deduce purchasing habits, assign relative priority of Internet search results, and predict traffic snarls. Computers play grandmaster chess, synthesize and recognize speech, discern faces in crowds and identify them, translate language, and drive cars. In 1960, these would all have been considered AI. Today they are something less.

The US Army Research Laboratory (ARL) depicts robot intelligence on a continuous scale, as in Figure 8. The remotely controlled "dumb" robots of today are at the left. At the opposite end are fully self-aware, autonomous entities. ARL strategy is to build robots with combined human and autonomous control, capitalizing on strengths of each and providing the flexibility to "plug in" new autonomous capabilities easily. This is shown graphically in the figure. Flexibility is key, since surprises are possible, even if unlikely. If an autonomous decision program eventually proves itself consistently superior to human beings at battlefield rules-of-engagement decisions, then autonomy shifts from desired to ethically required functionally. This topic has been explored (Arkin 2009) and vociferously debated (Gibson 2010) in the true fashion of a paradigm shift.

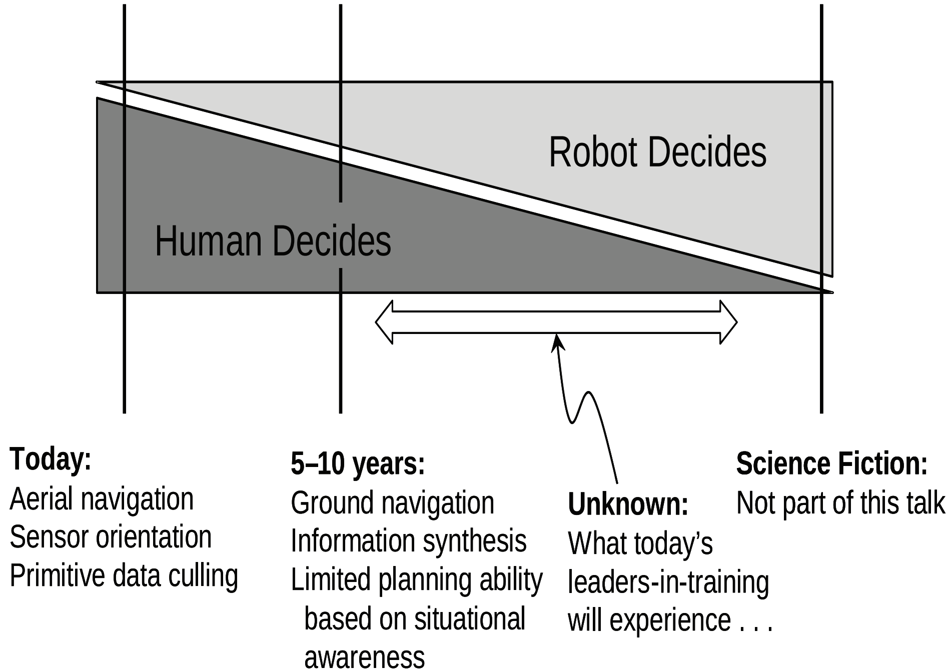

Figure 8. US Army Lab Concept: "Autonomy Scale" for Robots.

Source: Created by Author.

Autonomy, then, is not "yes or no," but a complex continuum. This way of thinking adapts easily to all three limiting factors—energy and bandwidth included—in the present analysis. In each case there is the current state, a most limiting future state, and a smooth transition between. It is not difficult to quantify, within an order of magnitude in each case, where technology must advance for revolutionary change to continue: weight per kilowatt-hour for energy systems, point-to-point bandwidth of data exchange for mobile *ad hoc* networks, and key forms of intelligence, for robots to be feasible performers of given military tasks. Even a cursory attempt indicates that progress at the present rate, continued over the next three decades, is sure to produce revolutionary capabilities, driving markets and future science as well as military affairs.

Having established the general structure of robotics revolution—RMA, paradigm shift, and/or industrial market disruption—we can turn to the resultant educational needs of military leaders.

Military Technology Adoption

Our specific goal is to provide leaders with an intellectual foundation to guide future decision processes of military organizations regarding battlefield robotics technology adoption. Envisioning the nature of those future processes is a necessary part of the framework we are creating. The clearer our vision, the better will be the final result. On the other hand there is the trap of excessive imagination. With apologies to Albert Einstein, our prediction should be “as detailed as possible, but no more so.” Unsupported conjecture will lead to an indefinite amount of missed opportunity. Obsession with unnecessary nuance will do the same.

The way forward is to follow Kuhn and Christensen with a “sciences of the artificial” approach by treating military technology adoption as a complex system with a model that can be validated through scientific investigation. Unfortunately, there appear to be no well-developed standard models of organizational technology adoption decisions (Brandyberry 2011).

What does exist? There do exist attempts to explain how people respond to new technologies at the personal level. *Information technology acceptance* (Davis, Bagozzi and Warshaw 1989) (Chau 1996) (Legris, Ingham and Collerette 2003) (Venkatesh, et al. 2003) and *technology adoption* (Bohlen and Beal 1957) models explain and statistically predict human choices regarding new technology. Technology acceptance is a sociological theory based on perceptions of the technology’s ease of use and usefulness. Characteristics of both the technology and the potential user population affect these perceptions, hence user acceptance. Predictive power of this model has been demonstrated for computer software acceptance. Technology adoption was originally formulated to explain how use of an improved breed of seed corn diffused through sub-populations of Iowa farmers. The empirical study considered the lifecycle from zero to 100 percent adoption and grouped farmers in categories based on how early or late each one chose to adopt the new seed. Statistically significant demographic and psychological characteristics were observed in each group. Since this groundbreaking effort, adoption modeling has become a standard technique in marketing (Mahajan, Muller and Bass 1990).

Though these classical models may be helpful at the margins for predicting how individuals will behave as robots proliferate, the larger concern of how large organizations will respond remains. Fortunately, we can look within military organizations themselves. Many have formalized their technology adoption decisions in acquisition processes. These can serve as Rosetta Stones for our purpose. Consequently, we will adopt an abstraction of military capability acquisition as a relevant model of technology adoption. Though our discussion is in the US context, the abstract model resembles processes of most other nations.

We hasten to add that we are not advocating that all leaders be educated as acquisition officers! Rather, for want of other alternatives, we are pressing a high-level view of acquisition into service as a roadmap for analyzing the needs of future leaders of robot-enabled forces, who will be coping with whatever the acquisition process produces and shaping it as stakeholders.

An Acquisition-Based Adoption Model

An abstract model of acquisition is needed to determine with high probability what future robot-induced change will mean for leaders at that time. Regardless of details, certain classes of decisions will determine the outcomes and thus are useful for our purpose:

1. Types and levels of R&D investment,
2. Which robotics technologies will be adopted,

3. How they will be employed, and finally
4. How progress will be evaluated and results fed back to affect future effort in a cyclic fashion.

Figure 9 depicts how these questions are answered systematically. R&D provides capabilities. The military, as “customer,” analyzes these for costs and benefits. Evaluations result in adoption decisions, which trigger planning at all levels. Production and implementation or “fielding” ultimately puts the new capabilities in soldiers’ hands. Feedback and feed-forward communications also occur at all levels while, simultaneously—formally and informally—theories, models and assessments are developed by individuals, small and large organizations, militaries, and nations. Each box of this diagram represents a complex activity, each a human endeavor spanning many organizations.

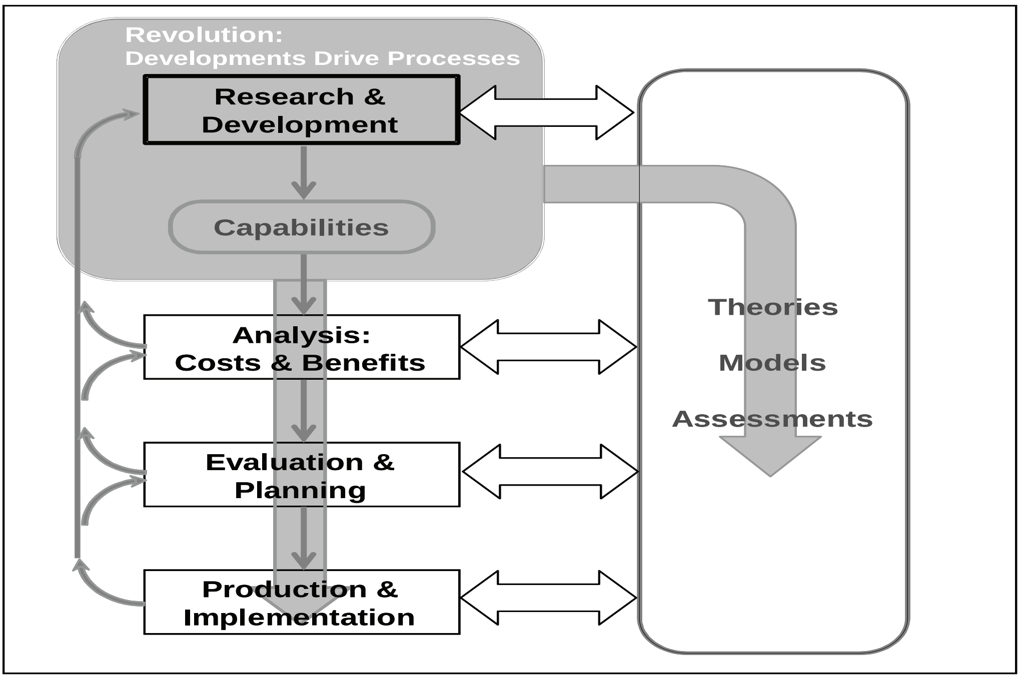

Figure 9. Revolution: Developments Drive Processes.

Source: Created by Author.

Acquisition systems are designed to drive and manage technological developments on a routine basis. Revolutions thwart this design by inverting it. Rather than systems driving developments, the opposite occurs. Developments drive processes beyond their capabilities. There is no routine. Reaction supplants planning. Consequently, special burdens fall upon leaders. They take up the slack of failing systems and make complex out-of-the-ordinary decisions about technologies and their employment. Simultaneously, they adapt the systems themselves to the new environment, even as they continue their functions.

There are recent examples of failure-driven reaction in acquisition, one even involving robots. In 2002, the US Army Rapid Equipping Force was created to quickly deploy small robots for cave clearance missions in Afghanistan because R&D and equipment fielding mechanisms were deemed too slow. The Joint Improvised Explosive Device (IED) Defeat Organization (JIEDDO) was established in 2006 to "defeat IEDs as weapons of strategic influence," (US Department of Defense 2006) primarily because traditional acquisition processes were unable to address this quickly emerging extant threat.

Model to Curriculum

The proposal of this paper, the answer to the "how" in the question posed in section 2, is to center officer education design on a careful consideration of this model along these lines:

1. The range of revolutionary capabilities likely to issue from R&D.
2. The nature of cost/benefit analyses that will be needed for deciding which capabilities to acquire.
3. The skills and value systems—scientific, engineering, political, economic, ethical, and other—that will play parts in evaluation and planning.
4. The knowledge of technology and the inspiration needed to implement successfully, even in the context of ongoing military missions.
5. Character and abilities needed to fill gaps when processes fail due to revolutionary change and to adapt the processes to the changed environment.

All broadly accepted methods of curriculum design (Romiszowski 1987) (Allan 2006) comprise a kind of "reverse engineering," beginning with *objectives*—what graduates of the desired educational experience should have the potential to do by some set future time. These objectives enable a firm description of needed knowledge and attributes. From these, individual programs infer *outcomes*—what students should be able to do at the time of their graduation. Specific fact and technical knowledge and skills, habits of thought, problem solving, critical and logical thinking, and communications abilities are all typical of outcomes. From outcomes flow course objectives: subsets of the outcomes served by each offered course. Finally, lesson content and methodology follow. The skilled execution of such reverse engineering is the role of Toffler's educator, discussed in the Introduction.

Early Insights

In this context, the purpose of examining the acquisition system is to establish educational objectives, a foundation for all that follows. The rest of the work is beyond the scope of this paper, but the analysis already in hand provides some early insights on what the final results might be. Knowledge components must include *Basic Sciences*: Mathematics, Computing, Physics, Chemistry, Biology. *Engineering:* Mechanical, Aeronautical, Electrical, Software Systems. *Humanities and Social Sciences:* History, Economics, Political Science, Psychology, Philosophy. *Personal Abilities:* think critically, adapt quickly, solve problems skillfully, respect scientific methodology, and seek out the right technology, understand people and society, decide and act ethically. In each area, it is apparent that fundamentals rooted in enduring principles are far more important than perishable facts and technological details that are likely to be superseded.

Not surprisingly, these comprise standard directions for most liberal educational programs worldwide, particularly the ones that characterize leader education. However, curriculum design is equally about what not to attempt. It is in making systematic tradeoffs within time and financial constraints that the objectives-outcomes-course design procedure pays off. It also provides the foundation for faculty-staff-student communication—a common language for articulating what is to be accomplished. It becomes "part of the air" as one faculty member has expressed it.

Another early insight has less to do with systematic design than faculty creativity and energy. Fast-paced response to a revolution demands proactive people who imagine a better future and energetically pursue it. Capturing imagination on technology's possibilities, encouraging initiative, and instilling a propensity for action with regard to new technology will be among the most important accomplishments of officer preparation for a robotics revolution.

Conclusion

We have examined current developments in military robotics, both at face value and with respect to three classical models of revolution and disruption. We found that the likelihood of change rising to the level of "revolution" by any reasonable definition is very likely. Details of this revolution are unknowable, but its shape will necessarily conform to norms of military technology adoption. These are embedded in the structure of systems for military acquisition, which is well-documented and understood, even if its efficacy is debated. If modern trends persist, robotics capabilities will be developed by science and engineering methods at ever-increasing rates and levels of sophistication. Despite strict constraints of physics and known limits of understanding, resulting capabilities are certain to alter basic assumptions of warfare.

Organizations at several levels will engage in a complex cycle of theorizing, hypothesis formulation, trials, implementation, assessment, and redirection of effort. In this manner, the military enterprise will decide which capabilities to acquire and how to apply them to best effect. This will encompass a large set a highly complex, multidimensional decisions incorporating many human and societal value systems. There will be successes and failures. Military leaders will inevitably bear responsibility for the results.

By analyzing acquisition processes, we can catalog the knowledge and professional attributes that leaders will need in order to understand and harness the potential of military robots. From this we can reverse engineer education to enable their success. This paper is a first step along that line of action.

Bibliography

ABI Research. *Defense Robotics, UAVs, UGVs, UUVs, and Task Robots for Military Applications.* ABI Research, 2011.

Air Force Times staff. "Moseley and Wynne forced out." *Air Force Times*, 5 June 2008.

Allan, Joanna. "Learning Outcomes In Higher Education." *Studies in Higher Education* 21, no. 1 (2006): 93-108.

Arkin, Ronald C. Governing Lethal Behavior: *Embedding Ethics in a Hybrid Deliberative/Reactive Robot Architecture.* Boca Raton, Florida: CRC Press, 2009.

Bohlen, Joe M, and George M Beal. "The Diffusion Process." *Special Report of the Agriculture Extension Service* (Iowa State College) 1, no. 18 (May 1957): 56-77.

Brandyberry, Alan. "A Conceptual Framework for Sequential Organizational Technology Adoption with Dynamic Goal and Action Portfolios." *AMCIS 2011 Proceedings.* Detroit, 2011.

Brooks, Rodney A. "Elephants Don't Play Chess." *Robotics and Autonomous Systems* 6, no. 1 (1990): 3-15.

Chau, Patrick Y K. "An empirical assessment of a modified technology acceptance model." *Journal of Management Information Systems* 13, no. 2 (1996): 185-205.

Christensen, Clayton, interview by Barry Shoop. *Course: Disruptive and Innovative Technology Ideation* (10 November 2011).

Christensen, Clayton M. *The Innovator's Dilemma.* Boston: Harvard Business Press, 1997.

Clapper, James R., et al. FY2009-2034 *Unmanned Systems Integrated Roadmap.* Washington, D.C.: U.S. Department of Defense, 2009.

Davis, Fred D, Richard P Bagozzi, and Paul R Warshaw. "User acceptance of computer technology: A comparison of two theoretical models." *Management Science* 35, no. 8 (1989): 982-1003.

Gibson, Andrew. *Andrew Gibson's Blog.* October 17, 2010. http://andrewgibsondefence.wordpress.com/2010/10/17/should-killer-robots-be-banned-publisher-leftfootforward-org/ (accessed 1 November 2011).

Headquarters, Department of the Army. "Unmanned Aircraft System Flight Regulations." *Army Regulation 95-23.* Washington, D.C.: Headquarters, Department of the Army, 2 July 2010.

Kuhn, Thomas S. *The Structure Of Scientific Revolutions.* 3rd. Chicago: University of Chicago, 1996.

Legris, Paul, John Ingham, and Pierre Collerette. "Why do people use information technology? A critical review of the technology acceptance model." *Information and Management* 40, no. 3 (2003): 191-204.

Mahajan, Vijay, Eitan Muller, and Frank M Bass. "New Product Diffusion Models in Marketing: A Review and Directions for Research." *Journal of Marketing* 54, no. 1 (1990): 1-26.

Markoff, John. "Google Cars Drive Themselves, in Traffic." *New York Times*, 9 October 2010.

Metz, Steven, and James Kievit. *Strategy And The Revolution In Military Affairs: From Theory To Policy.* Carlisle, Pennsylvania: Stategic Studies Institute, U.S. Army War College, 1995.

Osinga, Frans P. *Science, Strategy, and War: The Strategic Theory of John Boyd.* Abbingdon, Oxon and New York: Routledge, 2007.

Romiszowski, Alexander J. *Designing Instructional Systems: Decision Making In Course Planning And Curriculum Design.* London: Kogan Page Ltd, 1987.

Simon, Herbert A. *The Sciences Of The Artificial.* 3rd. Boston: MIT Press, 1996.

Thrun, Sabastian, et al. "Stanley: The Robot That Won the DARPA Grand Challenge." *Journal of Field Robotics* 23, no. 9 (2006): 661-692.

Toffler, Alvin. *Future Shock.* New York: Random House, 1970.

U.S. Department of Defense. "Directive Number 2000.19E." Washington, D.C.: Department of Defense, 14 February 2006.

United Nations. "Briefing Security Council, Us Secretary Of State Powell Presents Evidence Of Iraq's Failure To Disarm." *Press Release SC/7658.* New York: United Nations, 5 Feb 2003.

Venkatesh, Viswanath, M G Morris, G B Davis, and F D Davis. "User acceptance of information technology: Toward a unified view." *MIS Quarterly* 27, no. 3 (2003): 425-478.

Weinberger, Sharon. "Gates: Air Force Must Do More (Updated)." *Wired,* 21 April 2008.

Weiss, Lora. "Autonomous Robots in the Fog of War." *IEEE Spectrum,* August 2011.

Zorpette, Glenn. "Waiting for the Rapture." *IEEE Spectrum,* June 2008.

Chapter 15
An Assessment of Combatant Empathy for Robots with a View to Avoiding Inappropriate Conduct in Combat
by Serge Tisseron

Robots are already among us even though they usually go unnoticed. They answer the phone or operate certain means of transport, but they have not "materialized" into recognizable forms. Sometimes they even remain hidden so as not to cause users any anxiety. On the battlefield however, they are ever more present, and the trend is not about to be reversed. Indeed, robots are comparatively much cheaper than Western combatants, who are scarce and costly: deploying an American soldier for a year in Afghanistan is about the same cost as six PACKBOT robots, or US $150,000 (Singer P.W., 2009). Moreover, while Western public opinion has grown very sensitive to the notion of human loss, it is perfectly indifferent to the destruction of robots, seen as no more than machines.

But how does a combatant perceive robots? Everything changes for him the minute a robot is deployed on the battlefield. First of all, he can interact through the machine and see the world through its contact sensors. The battlefield almost turns into a virtual space insofar as he is now totally safe and able to destroy enemies which have become mere images on a screen. Likewise, the private on the ground will inevitably experience feelings of solidarity and bonding with autonomous machines capable of saving his life, even though such feelings are normally reserved for other human beings.

As we will see, these two changes have all sorts of consequences which all revolve around the notion of empathy. But let us first focus on what this word refers to.

A Mutual and Reciprocal Construct that Begins with Birth

The concept of empathy was introduced in the 19th century by Théodore Lipps as the foundation for a new type of psychology taking sensory and motor systems into account. It then fell into disuse in the 20th century as the focus was placed exclusively on language. Renewed interest in the concept is now being fuelled by findings in three different fields: cognitive science, ethology (empathy is essential in the animal world, especially among mammals), and research highlighting how communication is conditional on motor and emotional imitation. This research demonstrates that empathy is neither sympathy, nor sympathy in the literal sense, nor identification.

Sympathy implies sharing not only the same emotions, but also the same values and objectives. That is what the word "sympathizer" means.

Sympathy in the literal sense, or "compassion," as the French say, emphasizes suffering. It is inseparable from the notion of victims with whom you are siding against a hostile force, or even human aggression.

As for identification, it is but the first level of empathy. Indeed, empathy can be represented as a pyramid with three superimposed levels corresponding to relations both increasingly rich and shared with an increasingly limited number of people.

Direct (or Unilateral) Empathy

Direct empathy refers to what is usually called identification and can be defined as the ability to change viewpoints without losing one's bearings. Based on neurophysiology, it is always possible (except for people with autism spectrum disorders). It subdivides into two components as it consists in both understanding another's viewpoint (cognitive empathy) and feelings (affective empathy). Identifying with another does not imply totally putting ourselves in another person's shoes, but suggests that some resonance is established between what another feels and thinks, and what we feel and think ourselves. In the end, it involves being capable of imagining how we might feel if we really were in that other person's shoes. Identification does not require recognizing others as human beings. We can identify ourselves with cartoon or novel characters that we simply imagine. Identification with someone can occur without looking at them, and even without them noticing. For instance, I can put myself in the place of the waiter who is serving me lunch at the restaurant, and decide to tip him because I think that, if I were him, it would seem like the right thing to do, and yet not even look at him or harbor any feeling toward him.

Empathy thus defined can serve reciprocity just as well as psychological influence. In the former case, it leads to mutual support and solidarity; in the latter, it generates sometimes very subtle forms of mental and conscious manipulation.

Reciprocal Empathy

There is another definition of empathy which makes it a prerequisite ethical choice for any type of peaceful social organization. Beyond the possibility to access another person's inner world representation, this particular kind of empathy builds on a longing for mutual acceptance and on acknowledging that interaction with others is the best—perhaps the only—way to self-knowledge. Not only do I identify with the other person, but I also allow them to identify with me, or in other words, to put them in my shoes and thereby to have access to my psychic reality, to understand what I understand and feel what I feel. We perceive other men and women as endowed with sensitivity just as we are, and not as if they were mere inanimate things. Any relationship involving that aspect of acceptance "does not fictitiously construct its object, but indeed apprehends it in all its practical peculiarities" (Honneth A, 2005). As Emmanuel Levinas demonstrated in 2004, this sort of acceptance makes it possible to reconcile asymmetry and reciprocity. It can be associated with the mirror test. It involves direct contact as well as the whole gamut of expressive gestures such as smiles, exchanged glances and facial expressions, which are evidence that I accept to make the other person a partner of sensory-motor interaction. Conversely, the absence of such expressive mediation amounts to denying the other's existence.

There are three aspects to mutual acceptance: recognizing that others are just as capable of self-esteem as I am (narcissism component); recognizing that they are capable of loving and being loved (object relations component); recognizing others as subjects of rights (which is the component of relations to the group).

Such acceptance can also extend to the non-human world, in which case it typically implies a particular perception of animals, plants and objects that takes into account "the variety of existential meanings they have to those around us and to ourselves" (Honneth, 2005). In other words, this reciprocally empathetic outlook is based on respect for the diversity of meaning other human beings may have assigned to this world.

Intersubjectivity

Intersubjectivity consists in acknowledging that other people can help me shed light on certain sides to myself that I am not aware of. This is obviously what people seeing a psychiatrist do, but fortunately, it can also be true of people involved in a friendly or romantic relationship. That is when all barriers are brought down.[1] This longing for recognition in someone else's eyes has its origin in the very beginning of life when babies look for self-approval in their mothers' eyes. We then live the rest of our lives with the same desire, now expressed and played out through the privileged medium of the new communication technologies (Tisseron S. 2008). In every case, intersubjectivity implies admitting that other people can provide me with useful information on yet undiscovered aspects of myself. It is no longer about simply identifying with the other person, nor even about opening my inner self to them, and thereby acknowledging them as capable of identifying with me, it also entails discovering through their eyes that I am different from what I had been thinking, and allowing myself to be transformed by that discovery.

With intersubjectivity, the eye of the other is not necessary any more, although it has always been indispensable during the previous stages given that empathy as recognition was a prerequisite.

Soldiers, Empathy, and Robots

Let us now examine what insight those definitions give us on changes brought about by the development of military robots. There are actually four facets to this question: the special effort that Western armies are currently making to win the support of local populations; the tightened monitoring ground combatants are submitted to from the higher ranks; the rise of a new type of relationship between combatants of similar status; finally, the ties that might emerge between combatants and robots deployed in a given theater of operations.

Striving to Secure Local Support

Any Western intervention in a foreign country is now concerned with winning the trust of local populations (Tisseron A, 2007). In this respect, robots have a major drawback insofar as they are perceived as the technological offshoot of a society that has lost its soul. Human combatants should be present in the field, and this is not only to report on the reality of combat to those who do not go to war, in particular non-combatant populations and political decision-makers. Boots on the ground also serve as indispensable evidence that the country which has decided to deploy its soldiers has reasons good enough to have considered going to war and risking the loss of human lives. Moreover, a physical presence

1. This is what I have called "extimity-inducing empathy," after the concept of "extimity" I started developing as early as 2001 (Tisseron S. 2001). Extimity consists in allowing a few people—indeed, sometimes many people—access to some fragments of oneself that had so far been preserved from outside scrutiny (and therefore kept intimate) in an attempt to make those fragments acknowledged as worthwhile.

is essential in countries where force is deployed to show local populations that they are considered as human beings.

Likewise, giving robots the capability to open fire seems very risky as long as they are unable to tell a civilian from an enemy combatant. Autonomous armed robots are likely to ruin the credibility of an intervention supposedly grounded on protecting human rights. While a soldier who kills a civilian can be presented as a particular, isolated case, it will be difficult to rely on the same explanations if the culprit is a robot. The very notion of giving a robot the ability to kill will immediately be denounced by local populations—and possibly by part of the international community—as a case of intervening armies holding the natives in contempt. That is why it would be much wiser, apart from any other considerations, to entrust the decision to open fire with human operatives, so that local populations will not feel like their lives are in the hands of machines, which they would undoubtedly see as dehumanizing. The only actors that can possibly win hearts and minds are human combatants in sufficient number, capable of building interaction and mutual acceptance with local populations, which is the definition of second-level empathy as described in Figure 10.

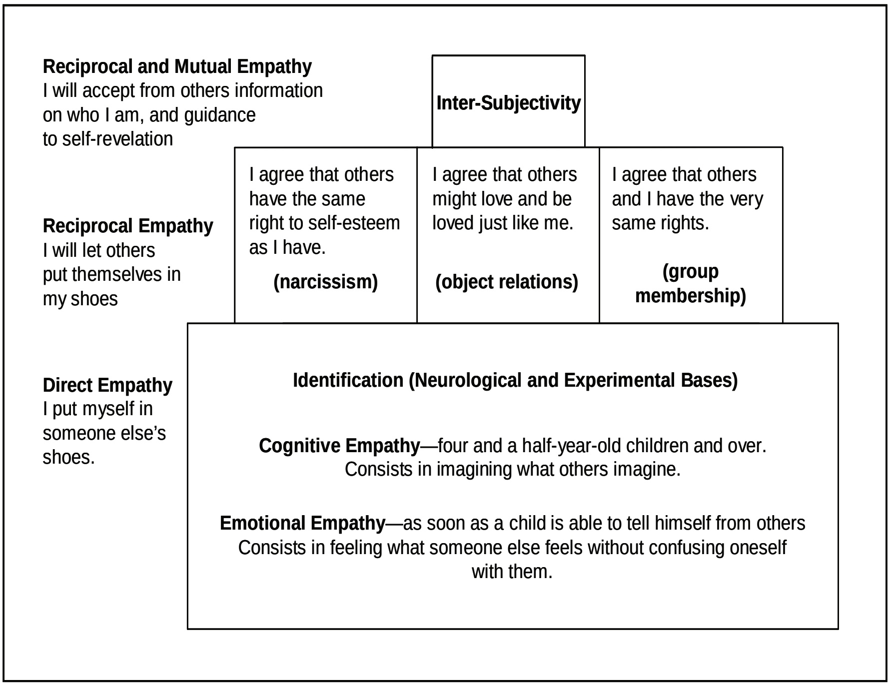

Figure 10. The Three Levels of Empathy.

Source: Created by Author.

The Temptation to Turn Ground Combatants into Robots

With current systems allowing data transfer by satellite, a subordinate tasked to operate a drone or a ground military vehicle can be under the direct supervision of an officer working in the same office. All a senior officer has to do, as he watches the control monitor over his junior officer's shoulder, is provide him with appropriate direction. However, this kind of supervision can also be exercised over ground combatants. Senior officers serving thousands of miles away from the theater have real-time access to the same information as ground combatants, and some might then be tempted to take maximum control of the operations from their distant, air-conditioned offices. They can see the battlefield as if they were there. For instance, some general officers might suddenly decide to take command and real-time supervision of all the details of the operations from their bunkers, or even from the US, while the fighting is actually taking place halfway around the globe. The risk then would obviously be for the officer on the ground to receive contradictory guidelines from several high-ranking officers supposed to provide him with the "right orders." Such a situation can only generate strong bitterness among ground combatants who might well start feeling as if they were treated like...robots, with no authority to open fire until some far-away officer decides otherwise! Mutual empathy between the various operatives might take a serious hit, just like cohesion in the long run, as brothers in arms on the ground and their counterparts in an office are likely to grow into two distinct, antagonistic corps. That is why the best rule might be to let the personnel fighting on the ground make the decisions and be accountable, participation in the action and presence on the theater taking precedence over rank. In short, the brass would identify the objective, and field officers, along with the other parties on the ground, would decide what means are necessary to achieve it.

This situation can be likened to the one organizing relations between virtual tutors and players in virtual environment gaming. When a player enters a networked game, like *World of Warcraft* for example, his "avatar" (or in other words, the pixel-made creature representing him on screen and making interaction possible) is always poorly dressed and armed at the beginning. To make his way to the top ranks, the player will have to rely on characters that are generated by the game software—these are called NPCs (Non-Player Characters)—and who will prescribe what objective he has to achieve, but never how to achieve it. Players are first expected to find the means they need all by themselves, and later through cooperation with other players, all the avatars teaming up to achieve the desired goal. In other words, the NPCs, who, just like guild masters to journeymen in bygone days, are both authority figures and initiators, only indicate the goal to reach and never the means to do so.

This paradigm would hardly be worth mentioning here if it had not already radically transformed the expectations that today's young generations confess having with regard to their elders. In a report published by the University of California—Berkeley, most teenagers polled declared that they wanted a pattern of relating to authority in which managers identify the objective to achieve, but leave them free to select the means to do so.[2] This is no doubt a good case in point for anyone trying to come up with a code of conduct destined to regulate relations between ground combatants and personnel in an office simultaneously processing information from the sensors of robots.

Exchanging Without Seeing One Another

Computers have made chatting and communication on forums a most commonplace thing. So for drone operators guiding their machines from a distant office to rely on computers to communicate should hardly come as a surprise. The problem is that civilian-life habits are likely to make those operators forget that the tasks they have to carry out are usually much more urgent! That is why the US military has banned using block letters and smileys in its communications (Singer P.W., 2009). Another issue that can hardly be brushed aside is that of trust. While chatting, we cannot see the person with whom we are communicating, and we never know who we are dealing with. Here again, it can be interesting to examine the standard practice in networked gaming, whose "fighters" find they have to depend on chatting to organize and regulate their relations on the ground, usually without knowing each other or ever having met. The stakes in the "fighting" involved are obviously quite different since death is virtual and never for real, but the question of the extent to which you can trust another combatant you know nothing about is essentially the same. This is of particular concern to players who have to submit resumes to belong to high-level guilds, and who sometimes live very far away from each other. The ability to coordinate everybody's moves, which is conditional on mutual trust, is indeed critical. This is one reason why some World of Warcraft guilds, including France's *Millenium* which for a long time was ranked first in France and among the best in the world, make it compulsory for all their members to attend In Real Life (IRL) gatherings once a year, and even several times a year for those members living in the same region.

Staff headquarters might be well-advised to think about the merits of such practices, and to consider organizing regular IRL meetings for combatants who have to fight side by side from their offices via computer screens and chat sessions. Similarly, it seems essential for such personnel to have experienced field maneuvers at one time or another. Indeed, the ability all soldiers have to imagine themselves in their comrades' shoes is central to the quality and efficiency or their collaboration.

Man-Robot Empathy

Of all the issues raised by the advent of robots, military or otherwise, the nature of the relation between man and a machine endowed with human features is beyond contest the most interesting one. Human beings can indeed empathize with both objects and other human beings (Tisseron S., 1999).

As a matter of fact, there is a human tendency to transfer all sorts of thoughts, emotions, and feelings onto animals, plants, and even inanimate objects around us. But these various

2. Mizuko Ito et al. *Living and Learning with New Media: Summary of Findings from the Digital Youth Project.* The John D. and Catherine T. MacArthur Foundation Reports on Digital Media and Learning, November 2008 http://digitalyouth.ischool.berkeley.edu/report, (accessed 22 October 2013).

kinds of projection are not subjected to the same appreciation. While transfer onto animals is valued, projection tendencies involving green plants are politely ignored, and those involving objects are generally singled out for derogatory comments. And yet this tendency testifies to an essential component of the human psyche: our sense of belonging "to the world" is proportional to our ability to endow this world with certain features of our mental life. In other words, we familiarize ourselves with objects by projecting our physical and psychological functioning onto them. This is our way to try to "understand" them, to be at peace with them despite all the things that make them so different, and also to attempt to ward off any possible object malfunction. For example, the more an object reminds us of a particular body part, the more we will tend to imagine its resilience and capacities with this same body part as a model. At the same time, the more we project ourselves onto them, the more comfortable we feel with them. Let us remember the jet pilots of the Second World War who would paint figures or names on their planes. In the *Buck Danny* comics I used to read as a child, pilots would give their autopilot systems human names.

This tendency is all the stronger as we are dealing with a machine of which we do not know anything. Knowing the way it functions makes it more familiar. Yet, as far as military robots are concerned, another element should not be underestimated: the transfer tendency is accentuated by the fact that combatants are going through highly stressful and emotionally wrought situations. The robot that comes along to participate in operations with them will be also easily perceived as joining the surrounding emotions too, especially if technology eventually allows it to display facial expressions similar to those of a human being.

The Issue of Appearance: Robots as Our Children

The more human features robots have, the stronger the empathy for them. Professor Hiroshi Ishiguro has designed the Geminoid series, whose eye contact, variety of expressions, synthetic epidermis, and hair implants are eerily realistic.[3] According to him, there are five levels of proximity between a robot and a human being:

1. Its appearance is close to a human being's (android robots)
2. Its movements mimic those of a human being (it can seize objects, walk, etc.)
3. Its sensory systems are almost similar to a human being's (it can see, hear, smell and feel)
4. It is capable of complex interaction with a human being (it can talk and answer, or even handle a conversation with a human being)
5. It can integrate into a social environment, learning from experience and furthering its ability to interact with the world just like a human being (Kaplan F., 2001)

3. See Advanced Telecommunications Research Institute International, "Geminoid" website at http://www.geminoid.jp/projects/kibans/resources.html, (accessed 22 October 2013).

When isolated, each of these characteristics makes relations between a human being and a robot smoother. Grouped together, however, they can become threatening. Indeed, there is documented evidence that the more a robot looks like a human being, the higher our level of trust in it—but only up to a point. When the similarities are too striking, our trust suddenly vanishes. A human-like robot becomes scary because it reminds us of zombies and ghosts, as robotics researcher Masahiro Mori pointed out in a famous article entitled "Uncanny Valley" (1970).

That is why tomorrow's robots are unlikely to look like the *Terminator* Schwarzenegger embodies in the eponymous film. Indeed, such a robot would be positively frightening. Conversely, if the human appearance of a robot is seen as uncanny, human-like attitudes and movements are reassuring, especially when evocative of childish behaviour: a good case in point here is Star Wars and its unforgettable R2-D2 which looks more like a barrel with legs than a human being. Still, we grow fond of the little thing the minute it starts stamping its small stumps in excitement.

Drawing from these observations, Hiroshi Ishiguro has designed a project aimed at giving a child-like appearance to those humanoid robots tasked to help human beings. The robots he designs are actually destined to take care of elderly people, an age category whose numbers will soon be so high in Japan that there will no longer be enough caregivers to attend to their needs. Who will do that job, then? Robots. But how to make worried and frail elderly people accept the care of a metal creature? To clear this obstacle, Hiroshi Ishiguro's vision is for people receiving a care giving robot in their homes to welcome it not as a machine, but…as their own child! The end goal is to make sure the robot will never appear as a threatening entity. For this goal to be reached, the robot must look like a young child rather than a grown-up. Its strength is of course much superior to a human being's, but its appearance must suggest innocence, fragility, and above all imperfection. Just like a child, the robot is helped up by its owner who makes it learn how to stand on its feet. What we have here is obviously a metaphor for giving birth, and we recall Steven Spielberg's *Artificial Intelligence* when the robot opens its eyes and memorizes its master's face, thus becoming able to distinguish it from hundreds, or even thousands of other faces.

Hiroshi Ishiguro has gone one step further, though: he came up with the clever idea that robot owners should educate their machines with…smiles. This is an idea that was obviously suggested to him by some psychiatrists. Early childhood educators know how pivotal mothers' emotions can be for babies in the process of constructing their perception of the world and of themselves. Take the example of babies having a hard time trying to walk: what do they do after their first fall? Try to get on their feet? Not at all: the first thing they do is look at their mothers' faces. If the mothers smile, the babies smile back, get to their feet, and start toddling again. If the mothers look worried or angry, they just sit still and start crying. Babies with smiling mothers gradually build confidence in themselves and their environments, and score high in both learning and self-esteem; conversely, babies faced with the second reaction are likely to grow insecure and stifled in their exploration capacities.

What Hiroshi Ishiguro has imagined for the education of tomorrow's robots is based on the same pattern. Those elderly people who will take a robot at home will not have to type on a keyboard to ask it to do the dishes or take them to their beds. They will simply program the machine with a smile! All they will have to do is smile while showing the robot how to perform a particular task, and it will try to reproduce what it will have been taught. If it succeeds, its owner's smile will encourage it to go further; should it fail to prove itself up to expectations, a disapproving frown will only inhibit its learning process. In a baby's life, this part is played by a privileged person called the child's "mother," even if the latter is an adoptive mother, or even a man in the case of same-sex couples. Using this term, Ishiguro has decided to call the owner in charge of educating the robot a "mother."

The consequences are huge: not only will this way of interacting strengthen the robot's ability to learn its "mother's" exact expectations, it will also make the "mother" particularly fond of "her" robot inasmuch as she had to rely on empathetic interaction with it throughout the learning program. So the project actually creates no less than the conditions for empathetic communication between men and machines, a form of empathy whose consequences are still unimaginable: indeed, human beings had never managed to create a child that would never leave them and serve them until death. Ishiguro has not simply invented a robot that will serve such practical functions, but indeed one that will probably also provide this kind of emotional assistance.

Will we be more or less human when we grow able to empathize with a robot? Neither more nor less, by all means, but the temptation will probably be great to communicate less with other human beings seen as different from ourselves, and to live surrounded by robots perfectly matching our particular expectations. In the long run, this sort of involvement might even grow more intense than the relations human beings normally entertain. Every robot owner will indeed be able to teach the machine what he or she likes, regardless of whether it is lawful or not. Now, some may wonder if this is not already what happens with our own children? Sure, except that children are not raised exclusively by their parents, let alone only by their mothers! The other parent is free to correct the noxious or antisocial effects of his or her privileged partner's education, and moreover, school later exerts yet another balancing influence. If the system currently developed by Ishiguro should come to be implemented on a large scale, I guess corrective action would be required, such as programming robots so that they automatically connect to the internet in order to rectify a potentially deviant or pathological "motherly" education. In short, a kind of evening class for robots, complementing their home education!

At any rate, if the scheme to turn a robot into the child of the person it serves is not without justification in the case of elderly people, the situation is much more complex when it comes to military robots. The danger would be for the soldier to develop an urge to protect the robot just like his child, at the risk of his own life.

A Matter of Confidence

Trusting one's teammates is a fundamental aspect of being a soldier, as it makes for better unit performance in combat. Let a robot save one or several lives, and it will immediately enjoy the confidence of human personnel. The problem is that such confidence could also generate reciprocal ties: the soldier trusts the machine that is protecting him, but also increasingly feels like he has to reciprocate by protecting the machine in return. The key role played by reciprocity in empathetic processes, and beyond that, in closely interdependent relations, should not be overlooked. A soldier might then very well hesitate to send the machine on a highly dangerous mission, going instead for an option in which his own life will be more at risk.

The risk for a relationship between a soldier and a robot to grow into a highly emotional involvement has been documented by research on pet robots, especially the *Paro* robot which is reminiscent of a baby seal. This artificial creature elicits from the elderly people to whom it is entrusted even more intense exchanges than might be observed with a real pet. Actually, it never eludes interaction and always displays continued attention to its conversation partners who get used to addressing it as they would a human being. Most people add that they really feel like it can understand them, although some are careful to point out that they know full well that it is simply not so.

In order to forestall such a risk, I believe it is better to avoid an overly personal relationship between the soldier and a robot that would be like his special machine, the one with which he might feel as if they were sharing the same combat experience. The point is not to determine whether the mobile, intelligent, autonomous robot will be accepted as a full-fledged partner by the human combatant; rather, it is to set limits to this type of reciprocity-based relations. To each personnel his robot sounds like a hazardous notion to me, as it might trigger uncontrollable transfer processes. Two identical robots for three personnel or three for five is a solution that could prevent any individual soldier from establishing an excessively personal relation with a robot to the point that he might put his own life on the line to save the machine. The rule according to which "no one should be left behind" can only apply to a robot if it is of vital interest to the group. But if a soldier came to feel so close to a robot as to risk his own life to save it, there would be no further point in using robots to save personnel's lives.

Mark Tilden, a physicist and a robotics expert, gives an example of this kind of excessively empathetic relation between a man and a robot (Singer P.W., 2009). He designed and built a mine-clearing robot in the shape of a stick insect. In the experience, the robot goes out into the minefield, stopping on purpose on every mine it comes across. It thus loses a leg every time it stops and goes on repeating the same routine until it no longer has any. Tilden explains that the US Army colonel in charge of the program could not bear watching the robot have its legs blown away one after the other until it turned into a burnt and damaged wreck slowly crawling to its last mine and complete destruction. This senior officer reportedly referred to the test as "inhuman," even though the mine-clearing robot, whose shape suggested a stick insect, actually looked like a plain eight-legged stick. One wonders how he would have reacted if the machine had been a humanoid robot and had lost a leg-like or an arm-like limb on every mine! The attitude of this colonel when faced with the "suffering" he imagines the stick insect robot to be in is clearly a component of his psychic life, so that even a course on the disposable dimension of robots is unlikely to make him see things differently. It would be more practical to have this aspect of his psychology mapped out early so he is never deployed with units that might be fielded with robots in high-intensity environments.

Actually, the tendency to see robots as equal partners varies from person to person. If all human beings are likely to feel close to the non-human world (Tisseron S., 1999), not everyone will form attachment bonds to the same extent, nor with the same intensity. For instance differences in behavior among soldiers using mine-disposal robots have been documented. Some personnel will quickly give them names, explaining that it makes identification faster than having to check their service numbers every time. Yet, such a practice is fraught with significance: naming the machine leads to assuming that it has its own personality, if only because it is identified exactly as an individual would be in everyday life. Such personalization makes the machine stand out as an individual, and reinforces its embodiment as a person. Unsurprisingly, those soldiers whose relation to the machine is mediated by a name will often try to use their own robots instead of their comrades.' Conversely, there are personnel who do not want to give their robots any individual markers other than service numbers, and who do not mind swapping machines: they are not "attached" to theirs.

Moreover, the example Tilden raises shows that even a robot in the shape of a stick insect is likely to elicit from a colonel such strong empathy as to make him forget that he was dealing with a pile of metal and silicon. For that reason, Peter Khan's suggestion that robots be given "slightly aversive personalities" (quoted by Singer P.W., 2009) can be a necessary step, though by no means sufficient. Even if robots are designed with a "slightly aversive personality," some soldiers will always have trouble getting over the destruction of a robot, and even worse, might grow so close to a machine as to endanger their own lives, or their comrades.'

And of course there is always the additional risk that an officer might end up feeling closer to the robots he uses than to the men and women he has under his command, especially in the case of a particularly sophisticated machine (let alone one that he might have programmed, independently of its military skills, to play chess with him for lack of any serious challengers in his unit).

In other words, taking care not to give the robot a human-like figure can only be part of the solution.

In order to guard against unfortunate surprises resulting from personnel growing too close to the robots under their orders, it would be wise to screen out all those personnel that are likely to form an excessively empathetic relation with the machines. Now, for such a screening process to be implemented, we need to develop a test measuring this attachment hazard and its consequences, and we could call it "test of personnel empathy for robots" (TPER). This test would make it possible to diagnose those soldiers that are likely to form such personal bonds with robots that they might stop considering them as mere tools, and possibly risk their own lives for them. Although we are now perfectly capable of measuring the forms of attachment to other human beings, we should urgently go further and start developing a test to assess the patterns of attachment to autonomous machines. Such a test would allow us to select soldiers able to be in charge of robots, with minimal risks of attachment and associated threats.

Only a test assessing the level of attachment to the non-human environment will enable us to relieve some soldiers from the responsibility of dealing with robots they might come to consider as full-fledged brothers in arms, and to exclusively entrust this kind of responsibility with those personnel that are the least likely to form an empathetic relation with the machines.

Which Robots for Which Soldiers?

The use of robots on the battlefield actually raises a number of issues which are not limited to whether or not they should be allowed to open fire autonomously, or what kind of local reputation they make for the armies that deploy them. Those issues have an impact on all levels of relations between men and machines, but also between superiors and subalterns and same-rank comrades. Robots in fact question all the military modes of operation insofar as they have the power to hyper stimulate ways of feeling, thinking and reacting that are functional in a robot-free environment, but no longer necessarily so in a world where they are actively involved. The empathetic relation human beings can build with their non-human environment is often the key to a sound use of machines; yet, it can prove devastating when applied to military robots.

That is why establishing a few useful guidelines in designing the robots, and preparing/selecting the combatants they will be deployed with, seems of vital interest to us.

Concerning Robot Design

From the outset, we should avoid giving robots an undue human-like appearance. It is much better to make them look like animals rather than human beings, and better yet if they more closely resemble insects than pets. The goal here is indeed the exact reverse of what pet robot designers try to achieve, especially when they have the elderly in mind. For senior citizens, features fostering attachment are essential, which is why pet robots typically look like children (a choice made by Hiroshi Ishiguro), or more often like pets (a dog, for example, or to avoid difficulties raised by robot movements, a big, immobile seal such as the *Paro* robot). Conversely when dealing with military robots, the objective is to prevent the emergence of excessively strong attachment bonds, although a relation involving a moderate level of commitment is necessary for soldiers to trust the robots. Machines looking like human beings, let alone children, should therefore be banned. Indeed, soldiers separated from their families for long periods of time might form such an unduly strong relation with this type of robots as to risk their lives for them. For the same reason, the appearance of a pet robot can be a problem. In the end, it might be better to give the robot the form of an insect, i.e. an animal that does not elicit any empathy in our Western cultures. However, this insect should not have threatening looks; so robots should be sophisticated enough for us to be able to talk to them and feel as if they understood us. By the same token, size matters. If robots work with combatants, they should be smaller than them so as not to appear threatening, yet not so small as to prevent soldiers from assuming they have the same perception of the environment.

Another vital aspect is to make sure that missions destined for robots can always be carried out by human personnel, so that the notion of a superhuman robot deserving top priority in terms of protection never surfaces.

Finally, robots must always be used in ways reminding combatants that a machine remains a machine. For this reason a robot must not be allowed to operate too autonomously, at least considering the present state of our relations to machines. When it comes to activating or deactivating a robot, the ultimate decision must be in the hands of the soldier. This reminder of the “machine” character of robots entails, among other things, the possibility to turn them into inanimate and interchangeable objects by removing a few circuits from them if they fail to meet our expectations.

A relatively flexible robot, for which soldiers would decide which program is best adapted to each mission, can therefore be imagined. It would permanently enhance the soldier’s identity as the one in charge, and give credit to his capacity to define the robot on an *ad hoc* basis. It would also make the robot less frightening as it would become no more than a modular machine to be adapted by the combatant himself according to his individual requirements. The more modular the robot, the lower the risk of excessive attachment because the relation will never be reciprocal: the robot certainly does not recommend transformations that the combatant would be expected to implement. The robot will then turn into a sort of Swiss Army knife whose pre-programmed behavior functions will be adapted by the combatant according to his needs.

If those conditions are met, robots will be acknowledged as constitutive of a third order of the animate world. We will be able to assume that they have their own way of experiencing the world—exactly as we do with animals. We will also be able to ask them to let us share what they experience, especially through the increasingly powerful sensor systems they will be fitted with. Yet, even if we do ascribe to robots the ability to think like us, our empathy for them will always be unilateral because we will not go so far as to consider that we might come to experience things the way they do. This is precisely what will always set the relation we will have with robots apart from the kind of relation we have with our fellow human beings...or at least with those human beings we have stopped considering as robots, see Figure 11.

Different Types of Relational Empathy	Other Human Beings	Animals	Real or Virtual Objects, Robots
Selfless Empathy: Thinking that other people have their own way of experiencing the world, and being able to put oneself in their place	X	X	X
Reciprocal Empathy: Accepting that other people can imagine putting themselves in my place	X	X	
Extimity Inducing Empathy: Accepting that other people, by putting themselves in my place, can help me access yet undiscovered aspects of my own self	X		

Figure 11. Empathy for Human and Non-Human Entities.

Source: Created by Author.

From a Combatant's Perspective

In order to prevent soldiers from forming an overly empathetic relation with their robots, all personnel should have basic knowledge of artificial intelligence and its ability to mimic human behaviour. However, in the thick of battle, it would be naïve to expect all future soldiers to believe, just because they were once told so, that a robot is nothing more than a piece of technology without any emotions whatsoever. Simply telling them is not enough, as evidenced by the example Tilden gives. The more sophisticated robots become in their ability to perform complex and varying tasks, the more indispensable it will be to distinguish those soldiers always capable of making the reasonable choice from those who are likely to make emotion-driven decisions resulting from various types of attachment they might have formed while operating with robots. It will then be possible to deploy the former along the robots in high-intensity environments, while the latter will preferably be employed for missions that do not require deploying robots, or for robot maintenance tasks. Differentiating between the various types of personnel will require developing a "test of personnel empathy for robots" (TPER) on the basis of the test of empathy for virtual creatures that we are currently working on. Robot appearance and soldier basic training are the keys to preventing certain drifts, but not all. The stress experienced in combat generates very strong needs in terms of attachment, and it would be very dangerous to underestimate them. It would actually be like confusing a human combatant for a robot, which is of course a total impossibility.

Conclusion

The deployment of armed robots on the battlefield obviously has a profound impact on many reference marks which all have to do with the ability to shift from understanding situations in terms of "either A or B" to understanding them in terms of " both A and B." A soldier operating an unmanned vehicle is both on the battlefield and away from it, while those personnel going to combat next to a robot must both consider it as a teammate when it protects them and as a pile of iron and silicon when they see it in danger and feel like protecting it.

Today, such a paradox may seem difficult to handle because most of us are the products of a book culture in which opposites are not meant to attract. Younger generations, however, have long been familiar with and intensely involved in digital technologies, and are trained ever earlier to constantly change viewpoints and reference markers. Will *they* be able, then, to "naturally" solve the paradox created by robots, and change perspectives on them as fast as the situation requires? Some will know how to do that, taking advantage of powerful skills in psychic plasticity generated by an extensive practice in changing viewpoints; but others will not.

Soldier training and preparation will therefore have to take into account two complementary aspects. First of all, it will have to be designed for the next generation of combatants to handle teamwork with robots in the best possible way. This part of the problem relates to the appearance of robots, their interfaces, and new cooperation and command practices yet to be invented. At the same time, the ability of each soldier to form with robots a relationship flexible enough to shield him from the danger of excessive empathy will have to be tested. It was the main purpose of this article to highlight this second problematic aspect, which, to the best of our knowledge, has never been explored so far, and to suggest implementing a TPER (test of personnel empathy for robots) as a possible solution.

Bibliography

Berthoz, Alain and Gerard Jorland. 2004. *L'Empathie.* Paris : Odile Jacob.

Bowlby, John. 1978, 1984, 1998. (Three volumes) *Attachement et perte.* Paris : PUF.

Honneth, Axel. 2007. *La réification. Petit traité de théorie critique.* Paris : Gallimard.

Levinas, Emmanuel. 2004. *Autrement qu'être ou Au-delà de l'essence.* Paris : Gallimard.

Lipps, Theodor. 1903. *Asthetik: Psychologie des Schônen und der Kunst,* Leipzig: Voss.

Kaplan, Frederic. 2001. *La naissance d'une langue chez les robots.* Hermès Science Publications.

Mori, Masahiro. 1970. Uncanny Valley. *Energy,* 7 (4): 33-35.

Pare, Zaven. 2010. *O robô e a maçã.* Rio de Janeiro : 7 Letras.

Rizzolatti, Giacomo (with Corrado Sinigaglia). 2007. *Les neurones miroirs* Paris : Odile Jacob.

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

Tisseron, Antonin. 2007. *Guerres urbaines: nouveaux métiers, nouveaux soldats.* Paris: Ed. Economica.

Tisseron, Serge. 1999. *Comment l'esprit vient aux objets.* Paris : Aubier.

Tisseron, Serge. 2008. *Virtuel, mon amour.* Paris : Albin Michel.

Tisseron, Serge. 2010. *L'empathie au cœur du jeu social.* Paris : Albin Michel.

Tisseron, Serge. 2012. *Rêver, fantasmer, virtualiser: du virtuel psychique au virtuel numérique.* Paris : Dunod.

Trevathen, Colwyn and Kenneth Aitken. 2003. Intersubjectivité chez le nourrisson: recherche, théorie et application Clinique. *Devenir,* Vol. 15, No. 4: 309-428.

Turing, Alan. 1950. Computing machinery and intelligence. *Mind* LIX: 433-460.

Part Three

The Future of Robots in the Military

Chapter 16
The Future of Drone Warfare[1]
by Noël Sharkey

The recent Iraq, Afghanistan, and Gaza conflicts have created a dramatic increase in the use of remotely piloted armed drones. With over 50 countries now buying and developing the technology, autonomous armed drones could become dominant in future war. Although there is currently a "man-in-the-loop" for all lethal targeting operations, that role is set to shrink rapidly as more autonomous operation becomes available. Current autonomous robots cannot discriminate between combatant and non-combatant targets, do not have battlefield awareness, cannot reason appropriately or make proportionality decisions. We point to the dangers of relying on future technological fixes and examine the impact on International Humanitarian Law. Military necessity is considered as a possible way to allow the new indiscriminate weapons to be deployed.

Proliferation

In the post-9/11 era, aerial drones have come to dominate military operations. Troop movements are almost always accompanied by intelligence, surveillance and reconnaissance drones. The military success of UAVs in the theater of war in Iraq and Afghanistan create massive worldwide demand for the technology. It is massive business. The Teal Group has estimated that the market will increase to $11.3 billion per year over the next decade, not including the billions of dollars in development costs. Teal does not have access to the figures for military robotics spending from major countries such as Russia, China, or Iran.[2]

There are now at least 50 countries using UAVs.[3] Many of these are being developed in-house and many are being bought in (and probably copied). The US sells many of its drones to its closest allies in Europe and recently the US company General Atomics has been given permission to sell its earlier generation predators in the Middle East and Latin America. Israel has an even wider range of markets, having recently expanded into Latin American countries. Countries that do not have the advantage of being a close ally of the US cannot yet buy armed drones, and so they are having to find other means of acquiring or developing them. India and Pakistan are working hard to develop attack drones, having failed to purchase any from the US or Israel. Russia has shown models of the MiG *Skat* unmanned combat aircraft, which is intended to carry out strike missions on air defenses. It is, according to reports from Russia, able to carry cruise missiles and can strike both ground and naval targets. Iran demonstrated a rocket launched UAV, the *Karrar* or ambassador of death, to the press in 2010. It carries two cruise missiles. It is not possible to ascertain how operational the Iranian and Russian craft are, but it is clear that, at the very least, they are moving in the right direction to make the technology.

China is showing the greatest commercial potential for selling armed UAVs over the coming decade. It has made a showing of many different types of UAV at its air shows over the last five years, some almost replicas of the US drones. The US-China Economic and Security Review Commission said that China "has deployed several types of unmanned aerial vehicles for both reconnaissance and combat."[4] According to the *Washington Post*, at the Zhuhai air show in China in November 2010, there were more than two dozen Chinese

UAV models on display.[5] Worryingly, the *Washington Post* article quotes Zhang Qiaoliang of the Chengdu Aircraft Design and Research Institute as saying, "The United States doesn't export many attack drones, so we're taking advantage of that hole in the market."

This is worrying because it indicates the opening up of a large and expanding market of which all the major players will want a share. If it looks like China's combat UAVs threaten to dominate the market, then others will start selling them and every developed nation will have them. This could have a significant impact on how disputes are handled and what constitutes a war.

Autonomy and the Pace of Battle

Since 2004, all roadmaps of the US forces have made clear the desire and intention to develop and use autonomous battlefield robots. Execution of these plans to take the human out of the loop is well underway. The end goal is that robots will operate autonomously to locate their own targets and destroy them without human intervention.[6]

Autonomous lethal targeting is not illegal so long as it accords with the principles of distinction and proportionality. In a military rich environment with few civilians in, say, a desert or at sea, there may be few problems with using armed robots to kill targets. Legally this may be little different from firing rockets from a distance, dropping bombs, or sending cruise missiles. However, armed robots are set to change the pace of battle dramatically in the coming decade. It may not be militarily advantageous to keep a human in control of targeting.

The speed of an unmanned craft is limited only by the integrity of its structure and components and not by human G-force limitations. Unmanned planes can not only travel faster than piloted planes but can also maneuver much faster, taking sharp turns that would kill a human pilot.

The US has been testing the supersonic *Phantom Ray* and the X-47b. The US Navy would like to replace the F-35s on their carriers with the X-47b.[7] The Chinese (Shenyang Aircraft Company) are working on the *Anjian* (Dark Sword) supersonic unmanned fighter aircraft, the first unmanned combat air vehicle (UCAV) designed for aerial dogfights. The US Defense Advanced Research Projects Agency (DARPA) and the Pentagon want armed unmanned vehicles that can reach anywhere on the planet within 60 minutes. The DARPA HTV-2 programme is a good example of the direction of technological developments. The *Falcon* HTV-2 is a hypersonic unmanned plane that in recent tests flew at a velocity of between 17 and 22 Mach, i.e. 17 to 22 times the speed of sound at its altitude. That is a maximum speed of 13,000 mph (20,921.5 kph), which is around 8.5 times faster than the Russian MiG-25, maximum velocity Mach 2.3 (1,520 mph or 2,446 kph).

However, as with any mobile system controlled by complex software we cannot predict how it will react in all circumstances. A series of unpredictable events could occur, or there could be an undetected bug in the program or a hardware fault. A hypersonic drone could be off target by 5 km in less than a second.

A simple example of just two interacting software algorithms running out of control happened on the Amazon website. The out-of-print 1992 book *Making of a Fl*y usually sells for around $50. But on 19 April 2011 Bordeebooks was selling it for $23,698,655.93

(plus $3.99 shipping) on the Amazon website.[8] This astonishing price was created because an automatic algorithm from bookseller Profnath was interacting with Bordeebooks' automatic algorithm. The story is that when Bordeebooks does not have a book in stock, they automatically list it at 1.27059 times the price of the highest other seller. So when a customer orders it from them, they can buy and sell at a profit. The problem was that Profnath's algorithm made their prices 0.9983 times the highest price of other booksellers. So each time Bordeebooks increased their price, so did Profnath, and they spiralled out of control.

This was quite harmless, as no one was prepared to pay these kinds of prices. However, imagine two or more complex algorithms interacting on high-speed armed robots. Without any knowledge of the other algorithms, there is no way to tell what would happen. They might just crash into one another or into the ground, or they might end up unleashing their destructive power in completely the wrong place. The point is that software algorithms on autonomous armed drones spiralling out of control is something to be very seriously concerned about.

As I have written elsewhere, allowing robots to make decisions about the use of lethal force could breach both the principle of distinction and the principle of proportionality as specified by international humanitarian law.[9] These are the pillars of the laws of war. Currently and for the foreseeable future no autonomous robots or artificial intelligence systems have the necessary properties to enable discrimination between combatants and civilians or to make proportionality decisions.

Under the principle of distinction, only combatants/warriors are legitimate targets of attack. All others, including children, civilians, service workers, and retirees, should be immune from attack. The same immunity covers combatants who are *hors de combat*—those who are wounded, have surrendered, or are mentally ill.[10] The principle of proportionality applies in circumstances where it is not possible to fully protect non-combatants in an action. It requires that the loss of life and damage to property incidental to attacks must not be excessive in relation to the concrete and direct military advantage anticipated.

Distinguishing between civilians and combatants is problematic for any robot or computer system. First, there is the problem in the specification of "civilian-ness." A computer can compute any given procedure that can be written as a program. We could, for example, give the computer or a robot an instruction such as, "if civilian, do not shoot." This would be fine if and only if there was some way to give the computer a precise specification of what a civilian is. The laws of war do not help. The 1949 Geneva Convention requires the use of common sense to determine the difference between a civilian and combatant, while the 1977 Protocol essentially defines a civilian in the negative sense as someone who is not a combatant.

Two major software components are necessary for robots to distinguish between combatants and non-combatants. The first is highly accurate and discriminative sensing and visions systems. While technology has improved dramatically over the past 50 years, the development of software for vision systems has been very slow. Currently we have vision systems that can detect whether something is a human or not by its shape, although these can easily be fooled by a mannequin or a dancing bear. We have face recognition systems that are effective so long as individuals stay still long enough to be identified, and we have various biometric tests for people who are stopped. In the fog of war all of these methods would run into insurmountable difficulties.

The second necessary component is reasoning from situational awareness. It is unclear as to when we might even get a foot in the door for this problem. There are always optimists, but the truth is that such systems are in the realm of “hope ware” rather than software. There is no way to be certain that they will never be achieved, but equally there is currently no evidence to suggest that they will ever be achieved. If they are achieved, it could be in hundreds of years.

In terms of the laws of war, we must go on the information and evidence that we currently have. We should not rely on technological fixes that are just around the very elastic corner that we may never reach. The bottom line is that autonomous robots that can kill without a human making the lethality decisions are indiscriminate weapons. They may properly belong in the United Nations Convention on Certain Conventional Weapons (CCW or CCWC).[11]

Military Necessity

The statement “Armed robots will always have a person somewhere in the loop for lethal targeting decisions” is often repeated by Western powers. But saying “somewhere in the loop” is not the same as saying that a human will always make the lethal targeting decisions. There are clearly instances where military necessity may override having anyone in the loop. In the extreme, if the very survival of the State was at stake and it was possible to use autonomous armed robots to save the day, it is fair to say that they would be used.

In these circumstances the use of autonomous killing machines may even be considered a legitimate action—or, at least, such an action might not be considered to be illegitimate if judged relative to the International Court of Justice’s decision, or more properly non-decision, regarding the use of nuclear weapons by States. As is well known, the Court ruled that, in the current state of international law and given the facts at its disposal, it was not possible to conclude definitively whether the threat or use of nuclear weapons would be lawful or unlawful in extreme circumstances of self-defense (circumstances in which the very survival of the defending State would be at stake).[12] It would not be too fantastic to imagine the phrase “autonomous armed robots” being substituted for “nuclear weapons.” Armed robots are a lesser beast than nuclear weapons—unless they are armed with nuclear weapons of course. So the substitution is easy. However, it is likely that it would take much less than the imminent collapse of a State before indiscriminate autonomous robots were deployed. History is littered with much examples in which humanitarian considerations have been overridden for the protection of soldiers rather than for the survival of the State from imminent collapse.

The attacks on the French market town of St. Lô during the Normandy invasion by allied forces in 1944 provide a good example of the indiscriminate use of air power. Although the town was full of friendly French civilians, an elite German Panzer division residing there was blocking the allied forces from breaking out of Normandy. Canadian, US and British forces took very heavy casualties. In response, according to Cohen, “The town was attacked on 25 July, by 1,500 heavy bombers, 380 medium bombers, and 550 fighter bombers, one of the largest air attacks in World War II. Panzer Lehr was virtually wiped out, and the town was turned into rubble."[13] The path was cleared for the allied advance, but many thousands of French citizens lost their lives in the process.

These actions were (and are still being) defended on the grounds that they were necessary to achieve military success. It is argued that the bombings were directly proportional to the military advantage gained. On the other hand, Walzer has robustly argued against the actions on moral grounds and in terms of just war.[14]

Another case of "military necessity" was the practice of US troops in Korea and Vietnam of firing back at targets in areas laden with civilians when they came under enemy fire. When the troops were pinned down they automatically employed tanks to return fire into hillsides as well as call for air strikes and artillery support. These actions, while saving the lives of US troops, indiscriminately killed civilian men, women and children.[15]

Cohen points out that this was not an illegal act. The law of war is not necessarily moral; it "allows troops under fire to fire back without ascertaining that there are no civilians mingled with the troops who are firing upon them. It allows troops under fire to fire back even if they know civilians are mingled with the enemy."[16] Does this means that if soldiers are fired on, then lethally autonomous robots could be deployed in the same way as artillery or indiscriminate air strikes?

If countries at war or in conflict have armed autonomous robots that will save many of their soldiers' lives, will the deployment of those robots be deemed a military necessity? If it impacts both on the protection of soldiers' lives and on the ultimate success of the mission, then there will be a great temptation to use the technology. Imagine a situation where UAV deployment is what is giving State A the edge in an armed conflict with State B. Now imagine that State A has its communications disabled and its radio and GPS signals jammed. If State A can return to its advantageous position using its stock of (indiscriminate) autonomous armed UAVs to maintain its advantage, will it not do so?

Pushing the point home further, suppose that, having disrupted the remote control of State A's UAVs, State B now deploys autonomous attack craft; will State A not follow suit? Will concerns about keeping a person in the loop or unleashing possibly indiscriminate weapons prevent the use of lethal autonomous UAVs? It seems unlikely that a country will lose a war because it decides that moral superiority is more important than victory.

Actions Short of Warfare?

Legal and political loopholes for drones are already being created in the US that give us some insight into what the future might hold when every major power is regularly deploying armed robots. Will drones change the definition of what constitutes a war? Will their use be considered to be an act of war, a policing action, or action short of war (under *jus ad bellum*)? US operations in Libya have sparked an argument between President Obama and the US Congress over the War Powers Resolution. The US 1973 War Powers Resolution limits the ability of a president to wage war without Congressional approval. The president is required to obtain congressional approval or terminate a mission within 60 days:

> [i]n the absence of a declaration of war, in any case in which United States Armed Forces are introduced—(1) into hostilities or into situations where imminent involvement in hostilities is clearly indicated by the circumstances; (2) into the territory, airspace or waters of a foreign nation, while equipped for combat, except for deployments which relate solely to supply, replacement, repair, or training of such forces.[17]

The President did not seek Congressional approval for the United States' role in NATO's Libya mission within the statutory 60 days. Harold Koh, the most senior lawyer in the State Department, has strongly defended the legality of US military involvement in Libya without Congressional approval. The argument was that since April 2011 the US's role in the NATO-led mission in Libya has mainly involved assisting in operations (refuelling and providing intelligence) and this complies with (2) above, or carrying out missile strikes with armed drones.

A report to the US lawmakers explaining why the president did not need to seek Congressional approval stated: "US operations do not involve sustained fighting or active exchanges of fire with hostile forces, nor do they involve the presence of US ground troops, US casualties, or a serious threat thereof."[18]

The actual wording of the 1973 War Powers Resolution concerns the introduction of *armed forces* into hostilities or into the territory, airspace, or waters of a foreign nation, while equipped for combat. The argument here would have to be that use of drone strikes in Libya did not constitute the introduction of US armed forces into hostilities or into foreign airspace.

There are at least two important questions that need be addressed here. The first is this: are drones now considered to be action short of warfare? As the White House told the *New York Times*: "American involvement fell short of full-blown hostilities."[19] The second question is, does the use of remotely piloted armed aircraft constitute the introduction of armed forces or not?

Although the US Congress has only been concerned about involvement in Libya, the use of drones for targeted killing has been carried out in at least three other countries that the US is not at war with: Somalia, Yemen, and Pakistan. Other than Libya, US drone operations in these countries are carried out by the intelligence services. Following the withdrawal of the QH-50 Drone Anti-Submarine Helicopter (DASH) in 1979, the Central Intelligence Agency (CIA) was the first in the US to use armed drones. In 2002 they killed five men travelling in a Sport Utility Vehicle in Yemen.[20]

Department of Defense lawyers considered this to be a legitimate defensive pre-emptive strike against Al-Qaeda. Since then, the use of drones for targeted killings or "decapitation strikes" in States that are not at war with the US has become commonplace.

Although the US will neither confirm nor deny the strikes officially, the *Asia Times* has called the CIA drone strikes "the most public 'secret' war of modern times."[21] The former Director of the CIA, Leon Panetta, has certainly been vocal about the operations. In 2008 he told the Pacific Council on International Policy, "it's the only game in town in terms of confronting and trying to disrupt the Al-Qaeda leadership."[22] Revealing the CIA's intentions regarding the expansion of targeted drone kills, Panetta went on to say of Al-Qaeda that, "If they're going to go to Somalia, if they're going to go to Yemen, if they're going to go to other countries in the Middle East, we've got to be there and be ready to confront them there as well. We can't let them escape. We can't let them find hiding places."[23]

Apart from Libya, none of the drone strikes in countries not at war with the US have even been considered by Congress under the War Powers Resolution. This is a dangerous precedent which is, at best, legally questionable under international humanitarian law as pointed out by Philip Alston, UN Special Rapporteur on extrajudicial killings. He challenged the legality of the targeted killings at a UN General Assembly meeting in October 2009. A request was issued for the US to provide legal justification for the CIA's targeting and killing of suspects with a question about who was accountable. The US refused to comment on what they said were covert operations and a matter of national security.

US Department of State legal advisor Harold Koh rebutted Alston indirectly, stating that "US targeting practices including lethal operations conducted by UAVs comply with all applicable law including the laws of war."[24] However, there are no independent means of determining how the targeting decisions are being made. It remains unclear as to what type and level of evidence is being used to make decisions that effectively amount to death sentences by Hellfire missiles for Non-State actors. The suspects are not provided with an opportunity to a appeal or even to surrender. It is also unclear as to what other methods, if any, are exhausted or attempted to bring the suspects to justice. The whole process is taking place behind a convenient cloak of national secrecy.

US law professor Kenneth Anderson questioned the CIA's use of drones in a prepared statement to a US Senate hearing:

> [Koh] nowhere mentions the CIA by name in his defense of drone operations. It is, of course, what is plainly intended when speaking of self-defense separate from armed conflict. One understands the hesitation of senior lawyers to name the CIA's use of drones as lawful when the official position of the US government, despite everything, is still not to confirm or deny the CIA's operations.[25]

A subsequent report by Alston in 2010 to the UN General Assembly describes drone strikes as violating international and human rights law because both require transparency as to the procedures and safeguards that are in place to ensure that killings are lawful and justified: "[A] lack of disclosure gives States a virtual and impermissible license to kill."[26] Some of Alston's arguments also revolve around the notion of "the right to self-defence" and whether drone strikes are legal under Article 51.

It appears that the US does not consider the CIA strikes or the deployment of armed drones in Libya as acts of war. How far will this go? All of the countries that have been subject to strikes are militarily inferior and pose little threat to western nations. It seems unlikely that more militarily sophisticated countries such as China or Russia would see such actions on their territory as actions short of war. The precedent is now in place and it will be interesting to see what happens when other countries start doing the same.

Conclusion

After nearly a century of development, the Unmanned Aerial Vehicle has become perhaps the most desired asset amongst the modern militaries of the world. The military successes of UAVs in post-9/11 conflicts has created a rapid proliferation of the technology. Although there is currently a 'man-in-the-loop' for lethal targeting operations, that role will shrink incrementally until there is a capability for fully autonomous operation. The autonomous functions are likely to be ready long before robots will be able to distinguish between combatants and non-combatants in any way that requires battlefield awareness. They will not be able to reason appropriately or to make proportionality decisions barring some incredible and unpredictable technological breakthrough.

Concerns over the proliferation of the technology were expressed in this paper. The United States and Israel are currently well ahead of the field in terms of armed robot planes, but that may change in the near future. Russia has plans for armed unmanned combat aircraft, Iran claims to have them, and China is catching up quickly. More than 50 countries have been buying and developing the technology. It was pointed out that China will soon start selling and exporting its armed drones on the international market.

If they are not stopped, autonomous drones will likely be the tool of choice in future wars. While there is a lot of talk that humans will remain in the loop to make lethal targeting decisions until the robots can be shown to be capable of obeying the principle of distinction, it is likely that military necessity will dictate that this constraint is dropped whether the robots are fully compliant with international humanitarian law (IHL) or not. The mantra could then change to "Don't worry, there will be technological fixes in the future." This is similar to what the US has said about not signing the treaty banning cluster munitions.

The eventual proliferation of autonomous armed robots raises many questions of concern. What will happen when two complex algorithms meet in battle? Will the use of drones lead to lowering the bar to war because they appear to make it "risk free"? Early indications from the current US administration is that drone use is already being considered an action short of warfare. What dangerous precedents are being set up by the current spate of CIA decapitations for when other countries have similar technology?

It is unclear what changes will need to be made to current international humanitarian law. IHL clearly covers the requirements for discrimination and proportionality. However, the mapping between the new technologies and IHL can be problematic when the operational detail of the new technology is not clear and keeps changing. Some clarifications and additions to IHL may be required, but it will be difficult to future-proof them. Armed autonomous robots are indiscriminate and disproportionate weapons and we must treat them as such now. As such the United Nations should consider placing them on the prohibited list of weapons under the Convention on Certain Conventional Weapons. We rely on possible future technological fixes at our peril.

Notes

1. Parts of this paper previously appeared in Noel Sharkey, "Drone Proliferation and the Protection of Civilians" in G.L. Beruto, (ed.) *International Humanitarian Law and New Weapon Technologies.* (Milan, 2012).

2. See Teal Group Corporation website: http://bit.ly/psA7rB, (accessed 1 September 2011).

3. I have personally read valid robotics reports for each of the following countries, and there may be many more: Australia, Austria, Brazil, Bulgaria, Canada, Chile, China, Columbia, Croatia, Czech Republic, Ecuador, Finland, France, Germany, Greece, Hungary, India, Indonesia, Iran, Israel, Italy, Japan, Jordan, Lebanon, Malaysia, Mexico, Netherlands, New Zealand, Norway, Pakistan, Peru, Philippines, Poland, Romania, Russia, Serbia, Singapore, South Africa, South Korea, Spain, Sweden, Switzerland, Taiwan, Thailand, Tunisia, Turkey, United Arab Emirates, United Kingdom, USA, Vietnam.

4. 2010 Report to Congress of the U.S.-China Economic and Security Review Commission, November 2010, 79. http://www.uscc.gov, (accessed on 23 October 2013).

5. William Wan and Peter Finn, "Global Race On to Match US Drone Capabilities." *Washington Post.* 4 July 2011, http://wapo.st/mfRa62, (accessed 10 August 2011).

6. Noel Sharkey, "Cassandra or the False Prophet of Doom: AI Robots and War" *IEEE Intelligent Systems* 2008 23(4): 14.

7. "USN Wants to Replace F-35s with UAVs" *Strategy Page,* 11 September 2011. www.strategypage.com/htmw/htnavai/articles/20110911.aspx., (accessed 11 September 2011).

8. Mike Eisen, "Amazon's $23,698,93 book about flies" *it is NOT junk* blog. 22 April 2011. www.michaeleisen.org/blog/?p=358, (accessed 10 September 2011).

9. Noel Sharkey, "Cassandra or the False Prophet of Doom," 14; Noel Sharkey, "Grounds for Discrimination: Autonomous Robot Weapons" *RUSI Defence Systems* (2008) 11(2): 86; Noel Sharkey, "Saying No! to Lethal Autonomous Targeting" *Journal of Military Ethics* (2010) 9(4): 299.

10. But see also John S. Ford, "The Morality of Obliteration Bombing" *Theological Studies* (1944) 5: 261.

11. United Nations Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons Which May be Deemed to be Excessively Injurious or to Have Indiscriminate Effects, in force since 2 December 1983 and an annex to the Geneva Conventions of 12 August 1949.

12. International Court of Justice, *Legality of the Threat or Use of Nuclear Weapons* (General List No 95) (8 July 1996).

13. Sheldon M. Cohen, *Arms and Judgment: Law, Morality, and the Conduct of War in the Twentieth Century* (Boulder, 1989), 34.

14. Michael Walzer, J*ust and Unjust Wars* (New York, 2006).

15. Michael Walzer, *Just and Unjust Wars.*

16. Sheldon Cohen, *Arms and Judgment,* 22.

17. War Powers Resolution of 1973, Public Law 93-148, 93rd Congress, HJ Res. 542, 7 November 1973, http://avalon.law.yale.edu/20th_century/warpower.asp (accessed 27 July 2011).

18. Letter from the President on the War Powers Resolution, 15 June 2011 www.whitehouse.gov/the-press-office/2011/06/15/letter-president-war-powers-resolution, (accessed 17 August 2011).

19. Charlie Savage and Mark Landler, "White House Defends Continuing US Role in Libya Operation" *New York Times,* 15 June 2011. www.nytimes.com/2011/06/16/us/politics/16powers.html?pagewanted=all, (accessed 3 August 2011).

20. Israel may have been using armed drones for longer but they denied this for several years despite eyewitness testimony. It cannot be verified here.

21. Nick Turse, “Drone Surge: Today, Tomorrow and 2047” *Asia Times*, 26 January 2010, www.atimes.com/atimes/South_Asia/LA26Df01.html., (accessed 17 July 2011).

22. Leon Panetta, “Director’s Remarks at the Pacific Council on International Policy, Central Intelligence Agency,” 18 May 2009. https://www.cia.gov/news-information/speeches-testimony/directors-remarks-at-pacific-council.html, (accessed 23 October 2013).

23. Leon Panetta, “Director’s Remarks at the Pacific Council on International Policy.”

24. Harold Koh, ‘The Obama Administration and International Law.’ Speech delivered at the Annual Meeting of the American Society of International Law, Washington, DC, 25 March 2010.

25. Kenneth Anderson, Submission to US House of Representatives Committee on Oversight and Government Reform Subcommittee on National Security and Foreign Affairs, Subcommittee Hearing, *Drones II,* 28 April 2010, [20].

26. Philip Alston, Special Rapporteur on Extrajudicial, Summary or Arbitrary Executions, *Report of the Special Rapporteur on Extrajudicial, Summary or Arbitrary Executions, Addendum, Study on Targeted Killings.* 28 May 2010. UN Doc A/HRC/14/24/Add.6.

Chapter 17
Developing and Integrating Unmanned Systems for Military Operations
by E. W. Powers

Abstract

Background

The integration of unmanned systems into military operations requires a comprehensive approach and detailed planning with regard to myriad challenges. These challenges include: technical, tactical, and economic hurdles, categories of Unmanned Aerial Systems (UAS) and whether to weaponize, force structure, Concept of Employment, Concept of Operations, Concept of Supportability, Command and Control, training, command and control (C2) networks, selection of controllers/operators, standardized Control Stations, and ethical and legal implications.

Results

Once a decision has been made to incorporate unmanned capabilities, how do we proceed to achieve our goals? Many of the questions and challenges have already been confronted and overcome by other nations and services. It makes sense to incorporate their lessons learned and to implement many of their solutions tailored to the individual cultures of services and the specific needs of the nation.

Conclusions

Most of the challenges faced by a military seeking to incorporate unmanned systems into their operational concepts have already been studied. Thus, it seems logical that any military anticipating an increase in the use of unmanned systems would review what other organizations have experienced in order to lessen their own learning curves and provide for a smoother transition to their incorporation and employment.

Introduction

Broadly defined, military robots date back to World War II and the Cold War in the form of the German *Goliath* tracked mines and Soviet teletanks.[1, 2] In more recent history, Unmanned Ground Systems (UGS) have demonstrated their ability to contribute to combat operations through their use in OPERATION IRAQI FREEDOM (OIF) and OPERATION ENDURING FREEDOM (OEF). Since operations in Iraq and Afghanistan began, more than 6,000 unmanned ground vehicles (UGVs) have been procured and deployed.[3] While not at the investment level of UAS, UGS have proven their ability to contribute to combat operations, particularly with regard to locating and neutralizing improvised explosive devices (IEDs). Unmanned Systems (UMS) technology is rapidly maturing. The advancement of UGS is dependent on a wide variety of technologies that are maturing at varying paces.

Warfighters today use many systems that would be considered unmanned systems, e.g. remote weapon systems, unattended ground sensors, networked munitions, ground based operational surveillance systems, etc. For the purposes of this treatise, a typical UGS may consist of:

1. Unmanned Ground Vehicle (UGV)—A powered physical modular system with no human operator aboard, designed to be able to control its sensing and action for the purpose of accomplishing assigned tasks in the physical environment. The UGV can include any and all associated supporting components such as operator control units (OCUs), power supply, common integrating software, payloads, intelligence, with human interface and command override capability.
2. Operator Control Unit (OCU)—A mobile device that allows the operator to control a UGV and receive data fed from the UGV sensors. Additionally, the OCU should be capable of controlling multiple types of networked tactical sensors and UAVs that are outside the scope of this roadmap.
3. Robotic Appliqué Kits (RAK)—An appliqué kit designed to provide fully integrated, safe and secure operation of existing vehicles with minimum modification to the host vehicle. The RAK system is nominally comprised of a portable OCU, vehicle mounted control modules, feedback interface, and an electro-hydraulic system.
4. Human Element—Although UGVs will have varying levels of autonomy, to include fully programmable mission planning, there remains a "man-in-the-loop" overseeing the actions of the UGV with the ability to change mission profiles on the move, and assume operator control.
5. Payload—the payload is the component of the UGV that allows it to accomplish its mission. Payloads include optical sensors for daylight navigation, IR and thermal sensors to "see" thermal images in day or night conditions, sensors that can detect various signatures with the capability of relaying them to an operator via the system's data links. Non-sensor type payloads include communications packages, weapons, explosives, electronic jammers, detection systems, manipulator arms, and cargo delivery.

Challenges

Why are unmanned vehicles so attractive? There are numerous reasons, but chief among them are the following:

1. Unmanned systems provide cost effective persistence, reach, striking power, and access.
2. Unmanned systems improve our understanding of air, sea, ground, and undersea domains.
3. Unmanned systems overcome the limits of human physiology.
4. Unmanned systems limit risk to military personnel.
5. Unmanned systems are force multipliers.

Despite the myriad reasons for increasing procurement and employment of UMS, there remain numerous challenges.

Technical

Critical unmet research needs in robotics for military applications include safe operations around humans, 360^{o} platform mobility, tele-operations, and human-machine interface. Issues to be addressed include developing advanced autonomous UMS that are able to make decisions in the field and execute tactical behavior changes to achieve goals; ability to respond to varying degrees of autonomous control exerted by controllers; platform mobility including power, energy, storage, and hybrid technologies; controllers, whether machine or human; and reliability, manufacturing, and repair.

In order to ensure that UGS are integrated into our structure and our concepts of operations, technology and platform matches must be monitored to ensure we do not ask for too much too soon and end up with a system that is unable to support our operations.

Tactical

UGS will likely become ubiquitous throughout the force. How these capabilities are organized and distributed will require a thorough review of ways and means to determine the optimal placement of each UMS based primarily on its function and how it can be best positioned and controlled to provide the best support.

Incorporation of UMS is an unresolved issue of when and how rather than "if." If UMS are to be utilized to their maximum utility, they will support and complement both airborne and land based systems. To provide maximum flexibility and basing options, it may well be that UMS must be multi-sited within the force.

Economic

As the cost of weapons systems, particularly manned aircraft skyrocket, it becomes more and more logical to procure weapons that are less expensive and, more importantly, reduce risk to our military personnel. The cost of one F-35 approximately equals one multi-mission UAS system consisting of 10–12 UAVs plus associated equipment.

Concepts of…

Employment

UGS-equipped platoons and squads will operate against enemies who know the complex terrain and understand friendly rules of engagement. They will be willing to fight in heavily populated urban areas and will rejoice in collateral damage caused by our operations. They will attempt to use the advantage of long, straight streets for long range direct fires and will use ground level, upper story, and subterranean avenues of approach and firing positions to engage from unexpected aspects. They will attempt to cut off and isolate Marines, working to overrun small units with the intent of capturing or killing Americans for information operations. Enemies will use obstacles to stop or channelize Marine forces in order to delay the force or inflict casualties. They will attempt to use time to their advantage focusing on delaying units long enough to tax their ability to resupply.

Operations

UGVs will likely be the predominant vehicles conducting missions within buildings, tunnels, and through hostile city streets. This requires that UGVs be able to operate in Global Positioning System (GPS)-denied areas, traverse stairs, deal with elevators, open doors and possibly even open windows, desk and file drawers, and cupboards. UGVs will need to navigate within and through city streets that may be busy with traffic and pedestrians. Urban streets also mean UGVs will have to contend with curbs, trash, water drains, etc. UGVs will have the unique requirement of dealing with changing terrain due to weather; UGVs must be able to travel on ground that is hard and stable one minute, and then becomes mud several minutes later. They must be able to navigate and maneuver in spite of dust kicked up by their own movement or windy conditions, as well as when the ground becomes slippery due to rain or freezing conditions. Snow accumulation becomes a terrain feature with which UGVs will have to contend, not only in terms of being able to travel while snow is falling, but also over roads covered in snow or ice. UGVs will have to be equipped with the sensors and perception algorithms to make decisions about when it is permissible to travel in these types of terrain or when it is better to delay the mission.[4]

Supportability

Requirements for austere basing drive key UGS supportability requirements with reliability, availability, and maintainability as integral design elements.

Reliability studies show that the Mean Time Between Failure (MTBF) for a UGV is currently 6 to 24 hours, well below the desired 96 hours.[5] Metrics for MTBF will need to be established to ensure that UGVs can reliably accomplish their missions once they have been deployed and employed. UGVs must routinely be ready for use. Availability will depend on several factors, most importantly reliability, the ability of manufacturers to provide vehicles, and the efficiency of the parts supply system.

UGVs will almost certainly be used in austere environments with little infrastructure support. Accordingly, they must be simple to maintain in an expeditionary environment, requiring primarily remove and replace maintenance actions to ensure that they remain simple and supportable by Marines using them in the field.

Command & Control (C2)

Command and control is the exercise of authority and direction over assigned or attached forces in the accomplishment of a mission; it is how the commander transmits his intent and decisions to the force and receives feedback. Command and control involves arranging personnel, equipment, and facilities to allow the commander to extend his influence over the force during the planning and conducting of military operations.

UGS will enhance situational awareness of commanders and leaders by providing near-real-time relevant information of the operational environment through the use of an open architecture. UMS must be able to ‘plug and play’ into the C2 system regardless of whether the operation is joint, coalition, or multi-national. These systems will feature a common control standard that facilitates interoperability with current and future communications systems and will continue to perform in a degraded or interrupted C2.

UMS should also be able to unplug from the common C2 system for limited duration when conducting small unit distributed operations. This will require a high-data-rate wireless local-area network, or network on the move. Without C2 architecture improvements, UGS and other new systems will not be employed to their full potential; at worst they could lead to risky commitments of weapons and forces beyond a commander’s ability to effectively control or support them.

In the future, UAS and UGS may need to be capable of autonomous cooperation. The UAS will preview the ground vehicle's intended corridor of advance, building a three-dimensional model of the terrain. The ground vehicle then plans a detailed route, avoiding obstacles that the UAS sees in the path of the ground vehicle. As the ground vehicle moves along, it compares its three-dimensional perceptions with the UAS three-dimensional map, registering the aerial and ground world models.

Training and Education

Effective training for the individuals selected to operate various UMS is the key to successful integration of UMS into military formations.

Training facilities must be equipped with the exact same controllers and vehicles as operators will use in combat operations. While simulators can provide an excellent basic framework for the strengths, limitations, and procedures required to efficiently operate UMS, the training cannot be so generic in nature that operators must learn or relearn the layout of equipment or the inputs required to successfully employ UMS.

The controllers/operators of remotely piloted aircraft (RPAs) must be selected based on a comprehensive analysis of their capabilities and their potential for successfully operating UMS. The question of whether they should be officers or enlisted, specifically trained to a military occupational specialty, or control UMS as a collateral duty is a moot point. The essential consideration is selecting the right people to operate UMS.

We must then identify, track, and manage critical skills related to unmanned capabilities, both for operators and maintainers. The manning required for UGVs may become a contentious topic. Although the long term goal is for UGS to reduce personnel requirements, the short term reality is that while they may reduce the number of personnel put at risk, there may be an increase in personnel requirements to operate and support UGS.

In addition to operators, the users of UMS capabilities and services must also be thoroughly trained in the employment, capabilities, and limitations of UMS. Whether they are Forward Air Controllers (FAC), Joint Tactical Air Controllers (JTAC), Forward Air Controllers, Airborne (FACA), Forward Observers (FO) or personnel who may be required to ask for UMS support, they must be trained, qualified, and certified to perform the actions for which they are authorized.

This brings up an important point if any UMS has a lethal role. One important question that must be answered is, *"Who owns the weapon?"* Implied in this question is precisely who has the authority to approve the lethal use of a UMS? Depending upon ROE, commander's intent, and the political situation, anyone fulfilling that role must be aware of the employment considerations and the impact of using lethal force with UMS. This, of course, leads directly to the issue of UMS autonomy. While we do not currently allow autonomous engagement of personnel, a strong argument can be made for autonomous engagement of other UMS, structures, or equipment. This will be one of the topics of heated discussion as the autonomy of UMS matures during the next decade.

A result of the relative immaturity of UGS on the battlefield is a lack of understanding and appreciation for the worth and value of UGS in operations. Operators and experienced users have great appreciation and respect for what these systems bring to the fight. Senior leadership should not have to wait until they are in the fight to learn the value of having this capability. They should be exposed to what the UGS can offer, how they operate, when they cannot operate, and how they can be incorporated into the scheme of maneuver at the earliest opportunity. UGS employment should be taught as part of career and top-level school curriculums. A high degree of inefficiency is introduced when commanders routinely request a higher degree of "control" over an asset than is tactically necessary. Leadership will be best served if they understand and appreciate UGS employment and operations.

Legal and Ethical Implications

The hope that technology will reduce the violence of war is a venerable one. The poet John Donne suggested in 1621 that the invention of better cannons would help limit the cruelty and crimes of war, "and the great expence of bloud is avoyed." Richard Gatling hoped his new fast-firing gun would serve to reduce the bloodshed of war, while Alfred Nobel believed the explosives he invented would make war unthinkable.

The military use of UMS has been thoroughly reviewed and found to be in compliance with the western view of legal warfare. The primary considerations are:

1. Conform to major tenets of laws of war.
2. Proportionality: no unnecessary violence.
3. Do not intentionally kill civilians.
4. Operator conforms to rules of engagement.
5. Man-in-the-loop in target identification to assure enemy combatant; man-in-the-loop during engagement to minimize civilian casualties.
6. Adheres to the Principle for Humanity or Unnecessary Suffering.
7. Weapons should not cause undue suffering.
8. Legal review by HQDA: consistent with international legal obligations.

Existing documents that guide the use of UMS include the 1988 Intermediate-Range Nuclear Force (INF) Treaty which prohibits testing, production, or launch of nuclear and conventional ground-launched cruise missiles with ranges between 500 and 5,500 km and the Missile Technology and Control Regime (MTCR) which restricts the proliferation of missiles, rocket systems, and/or UAVs capable of carrying 500 kg payload 300 kilometers, and systems intended to deliver WMD.

Unmanned systems seem to offer several ways of reducing the mistakes and unintended costs of war. They have far better sensors and processing power, which creates a precision superior to what humans could marshal on their own. Such exactness can lessen the number of mistakes made, as well as the number of civilians inadvertently killed. Now, some analysts believe that "robot warriors" can help reduce the flow of blood and perhaps make war more moral.

However, when considering lethal engagements and the taking of life, current policy demands that there be a human-in-the-loop to make the final life or death decision. The near future may see a human-on-the-loop methodology that requires human intervention only in the case of uncertainty or to comply with ROE. The lethal engagement of enemy personnel requires that the operator conforms to ROE and that there is a man-in-the-loop positive identification (PID).

Recommendations

In order to set the conditions for successful implementation of UMS, there are several important steps that must be accomplished.

First we must examine future scenarios and desired capabilities to determine what we think will be the most likely and most dangerous scenarios so that we can organize, train, and equip our forces accordingly.

Next we must identify the capability we have today. By comparing and contrasting current capabilities with what we think the future scenarios will require, we will be able to formulate the difference and what equipment will help in successfully dominating the future environment.

Given that we have determined the shortfall between today's capabilities and what we think will be required in the future, we can identify actions required to get to future capabilities. We must match those compelling future requirements to UMS capabilities then identify and sequence actions to enable fielding of UMS capabilities. Then, of course, the hope is that the future we have identified and the future that actually occurs bear some similarity.

We must identify those lessons learned that are relevant and that will speed our learning and acquisition processes. For example in planning the employment of armed UMS we must consider such intangibles as positive identification, target location, collateral damage estimates, and the availability of trained controllers and operators. There are myriad reports and lessons to be gleaned regarding the use of UMS in a Joint/Multi-National/Coalition environment. These lessons are particularly of use in training and in planning for future operations employing UMS.

Conclusion

Unmanned systems must be useful to the Warfighter. They can conduct persistent Intelligence, Surveillance, and Reconnaissance (ISR), provide logistics support to small units and dispersed formations, and can provide force application, including targeting and kinetic and non-kinetic fires, while protecting the force through standoff from threat capabilities. UGS will enable sustainment and force support operations through the increased automation of critical missions, including: assured mobility, transportation, distribution, maintenance, explosive ordnance disposal, crash-fire-rescue operations, communications, and health services. UMS will enable employment of integrated teams of air, ground, and maritime unmanned and manned systems for combat, combat support, and combat service support capabilities to defeat adversaries under any foreseeable conditions.[6]

The UGS enhances the ability to execute high-tempo combat operations with confidence. This includes agile support to ground forces through simultaneous insertions of sustainment items at multiple objectives—followed by robust sustainment of that force. UGS provide in-theater commanders at all levels with more options and greater flexibility in the execution of the campaign plan. The capabilities offered by the UGS directly result in shorter campaigns, fewer casualties, and mission success. They not only offer commanders a quantum leap forward over today's capabilities, but a force multiplier that transforms emerging operational concepts into reality.

Notes

1. The *Goliath* tracked mine (complete name: Leichter Ladungsträger Goliath (Sd.Kfz. 302/303a/303b)) was a remote controlled German-engineered demolition vehicle, also known as the beetle tank. Employed by the Wehrmacht during World War II, this caterpillar-tracked vehicle was approximately four feet long, two wide, and one tall. It carried 75–100 kg (165–220 lb) of high explosives and was intended to be used for multiple purposes, such as destroying tanks, disrupting dense infantry formations, and demolition of buildings and bridges.

2. Teletanks were a series of wireless remotely controlled unmanned tanks produced in the Soviet Union in the 1930s and early 1940s. They saw some use in combat during the Winter War. A teletank is controlled by radio from a control tank at a distance of 500–1,500 meters, the two constituting a telemechanical group. Teletanks were equipped with DT machine guns, flamethrowers, smoke canisters, and sometimes a special 200–700 kg time bomb in an armored box, dropped by the tank near the enemy's fortifications and used to destroy bunkers.

3. Office of the Secretary of Defense, Unmanned Systems Integrated Roadmap (FY 2009-2034), 2nd Edition, 6 April 2009.

4. Office of the Secretary of Defense, Unmanned Systems Integrated Roadmap.

5. Jennifer Carlson and Robin Murphy, "How UGVs Physically Fail in the Field", *IEEE Transactions on Robotics,* Vol. 21, No. 3, June 2005: 423-437.

6. Army Capabilities Integration Center (ARCIC)-TRADOC, Initial Capabilities Document for Unmanned Systems (Air, Ground, and Maritime), 2010.

Chapter 18
The Use of Robots on the Battlefield: Benefits, Constraints, and Limitations for Soldiers*
by Gérard de Boisboissel

Introduction

Future conflicts will combine—barring the use of customary armed forces in conventional warfare—conflict asymmetry with unclear, moving boundaries and criminal/terrorist acts that will be on par with military action.

Military power will thus have to adapt and be more flexible just as recent conflicts have already shown how wars are now conducted. It can therefore be recalled that:

1. The Joint Tactical Group of Kapisa—also known as "Task Force Korrigan"—was a French battalion stationed in Afghanistan's Kapisa Province. It adopted the strategy of World War II German *KampfGruppen* as a basis for their tactics in the Afghan war.
2. The area a soldier should control on the battlefield has considerably increased in the last century due to the scarcity of military resources and the relative insecurity in insurgent areas.
3. Most military operations at the international level are intended to be joint/combined operations. This requires a great deal of coordination and constant information exchanges with a clearly defined hierarchy within the Coalition Force.

These are just a few examples of the changes that have arisen in recent conflicts. Robots are new components and are changing the nature of war. As tools at the service of soldiers, they undeniably bring new capabilities to armed forces, but only if implementation constraints are not obstacles to their acceptance or use.

Expectations and Advantages of Unmanned Systems

To start with, it is worth considering what we expect from robotic systems:

1. First, robots are used for protection, i.e. to reduce the exposure of a soldier to risks. For instance, assistance in demining, help in mission reconnaissance, protection of convoys in risk zones, clearance of contaminated areas (CBRN: Chemical, Biological, Radiological, and Nuclear areas). They create a greater distance (standoff) from combat threats, are the first to take on the shock before infantry, and can detect the exact location from where shots are fired. They can respond in real-time in a few milliseconds, as Counter Rocket Artillery Mortar systems do, with an embedded decision-making system.

This article originally published in Vaclav Krivanek and Alexandr Stefek (eds.) International Conference in Military Technology Proceedings (ICMT), (Brno, 2013), 1359-1370.

2. Robots are also there to increase the effectiveness of a fighting soldier, bringing tactical advantages in executing his/her mission. They are used most notably to extend areas of control and coverage of a tactical unit, see Figure 12. This is done by using remote effectors, sensors, and weapons placed on-board each robot. In a sense, they are the "remote organs" of a soldier's eyes, ears, arms, touch, and even mouth.

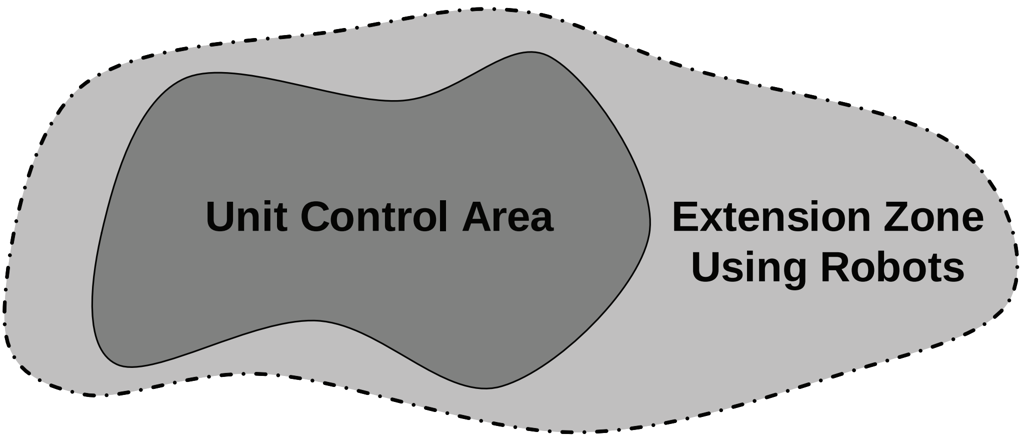

Figure 12. Robots Extend the Unit Control Area.
Source: Created by Author.

3. Robots can have much higher deployment speeds than Man. This can help in anticipating enemy actions or reacting immediately to a threat with greater efficiency. Robots can also help in maneuvers by identifying terrain features to facilitate progression, carrying out terrain preparation, or securing a given area. They are more accurate than humans for performing specific data processing needs, including threat warnings and identifying targets.
4. Finally, robots are a help in reducing human energy: they can replace soldiers in repetitive, tedious tasks (surveillance missions and regular patrols, transport logistics and general supplies), making room for operational forces to act when needed. Robots can also help the fighter by carrying supplies, ammunition and even weapons during long-distance missions (ground grid level, infiltration). On a more strategic level, robots reduce attrition as combat operations continue, enabling fighting units to stay on the battlefield much longer than before, see Figure 13.

Such expectations provide a wide range of benefits for military forces. The spectrum is still very broad and the assumption is that each country will develop specific national systems. In this regard, at the "Robots on the Battlefield" International Symposium organized by the Saint-Cyr Military Academy in 2011, the French Chief of Staff proposed the following:

1. Enhance the capabilities of combined Task Forces in Contact Intelligence solutions.
2. Improve the capacity to detect, identify, neutralize, and destroy mine/ explosive threats.
3. Complement the destructive capability of Task Forces in fire delivery and the use of weapons.
4. Participate in forward logistics (supplying soldiers during combat).[1]

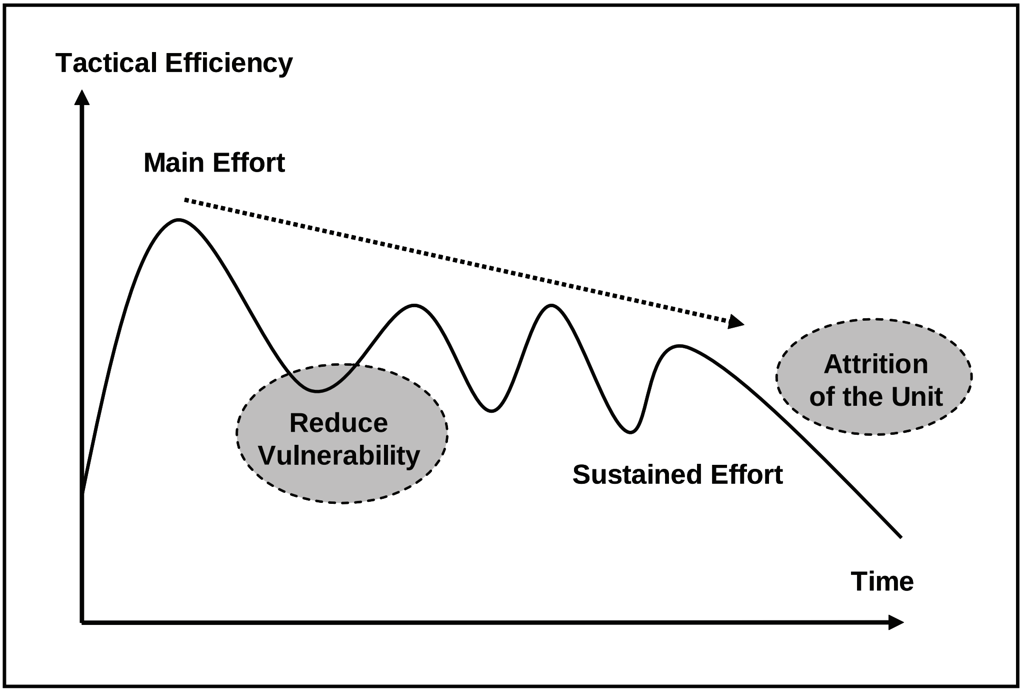

Figure 13. Robots Reduce a Unit's Attrition Through Time. [2]

Source: Created by Author.

Forward-looking tactical scenarios are presented below.

Forward-looking Scenarios for the Use of Robots by a Combat Section or Platoon

Lieutenant O'Kill Scenario: Use of a Robotics Screen prior to the Advance of his Platoon

We are in the year 2030. Lieutenant O'Kill's mission is to make a reconnaissance of an axis point in a valley. He has been instructed to protect the life of his men as far as possible. He liaises with the Theater of Operations Command through satellite communications and has several robotized squads at his disposal: a fire support and protection squad with armed Unmanned Ground Vehicles (UGVs), two recon squads equipped with UGVs and semi-remotely piloted Unmanned Aerial Vehicles (UAVs), and an Explosive Ordnance Disposal squad (EOD) to deal with potential IED (Improvised Explosive Devices), and robots to support and alleviate the burden on combat troops.

Lieutenant O'Kill requests the Theater of Operations Command to take over the control of his unit's robots, to serve as a flank guard on the east side of the valley. The unit's mission is deemed secondary due to visibility and its position in an open field. Hence, Lieutenant O'Kill does not want to take any chances. To proceed with greater security, he gives the order for robot operators to dismount from vehicles and places them near his command, see Figure 14.

The remote control of the robots is set to match the maximum firing range of weapons supplied to the unit (600 meters). The UGV is hence set at this range (with encryption depending on distance and the type of robot) and the UAV range is set at 2000 meters.

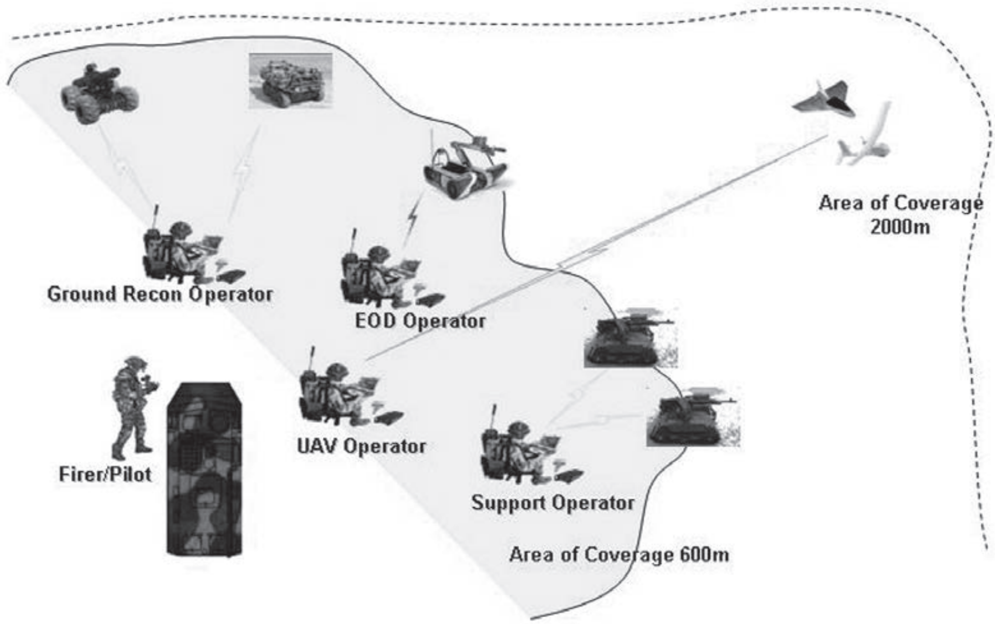

Figure 14. Deployment of Robots.

Source: Created by Author.

Before giving his troops the order to move forward, Lieutenant O'Kill launches UAVs to observe the area and its surroundings. He then sends a UGV for a reconnaissance mission along the axis, just ahead of the platoon. If an IED is detected, EOD operators are then in charge to send a robot to destroy the device(s) as illustrated in Figure 15.

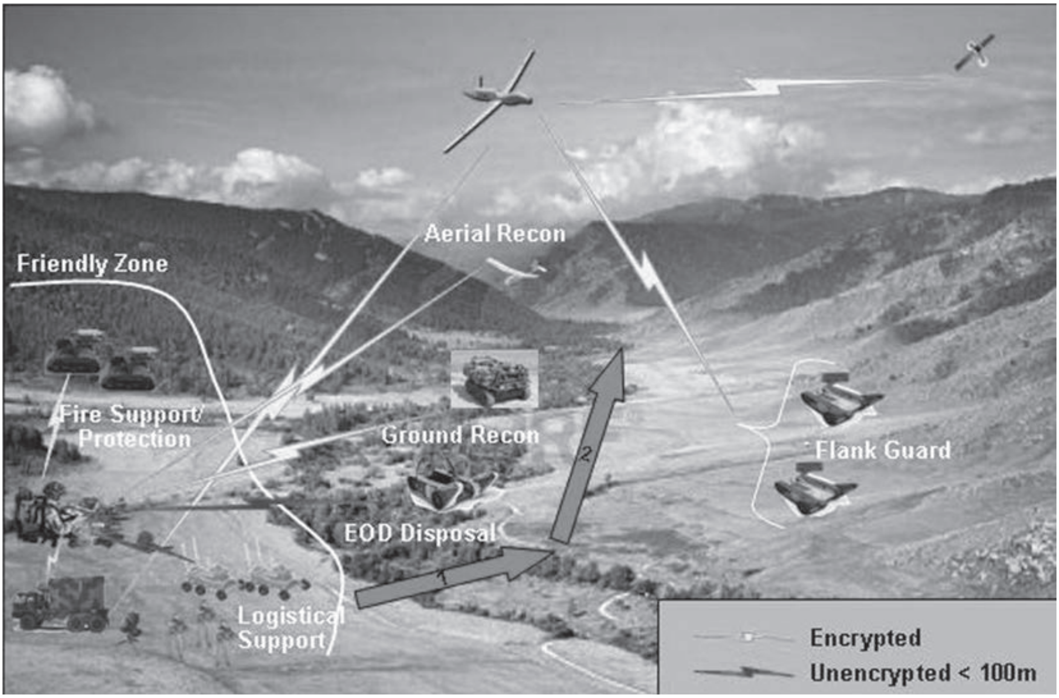

Figure 15. Lieutenant O’Kill’s Scenario.

Source: Created by Author.

Let us now analyze the constraints faced by Lieutenant O’Kill’s platoon and offer some remarks:

1. Preparatory phase: the lieutenant should configure each robot for its specific mission.
2. Platoon transport: both soldiers and robots have to be transported to the field of operations. Yet, there is limited room in combat vehicles. The next generation of combat vehicles will need extra space for the transport of robots or a separate transport should be envisaged.
3. Mini UAV Operators can operate remotely within vehicles, but UGV Operators should operate dismounted from vehicles for two reasons: a) for better visibility and b) to monitor operations.
4. Lieutenant O’Kill has multiple responsibilities: field reconnaissance, surveillance, flank protection, and supporting and protecting his soldiers. He therefore needs to perform a multi-robot control exercise. This requires an operator within his platoon to achieve the results he wants in the field. He has the support of the Theater of Operations

Command providing him remote operators, via satellite, for protecting his flank. Robots used for flank protection can be dispatched to units when requested, from a pool of robots in reserve.

5. There are several operators in this scenario. This is a risk as they need to be replaced if unfit for combat. Can the Army afford hiring extra operators and train them for such a task? The best solution is to train operators who are able to control several robots.
6. Lieutenant O'Kill's disposition is complex, but must nevertheless remain very discreet and fluid in use.
7. Managing various robotic systems in the platoon implies repeating main mission orders for each robot operator.

Lieutenant Safetown's Scenario: Use of Robots in an Urban Offensive

We are in 2025. Lieutenant Safetown has been ordered to make a reconnaissance of a town where insurgents have been spotted the previous day. The risk is high of being shot by a sniper or by insurgents hiding in a building. The tension is high within the platoon and everyone fears for his/her life and the lives of their comrades in arms.

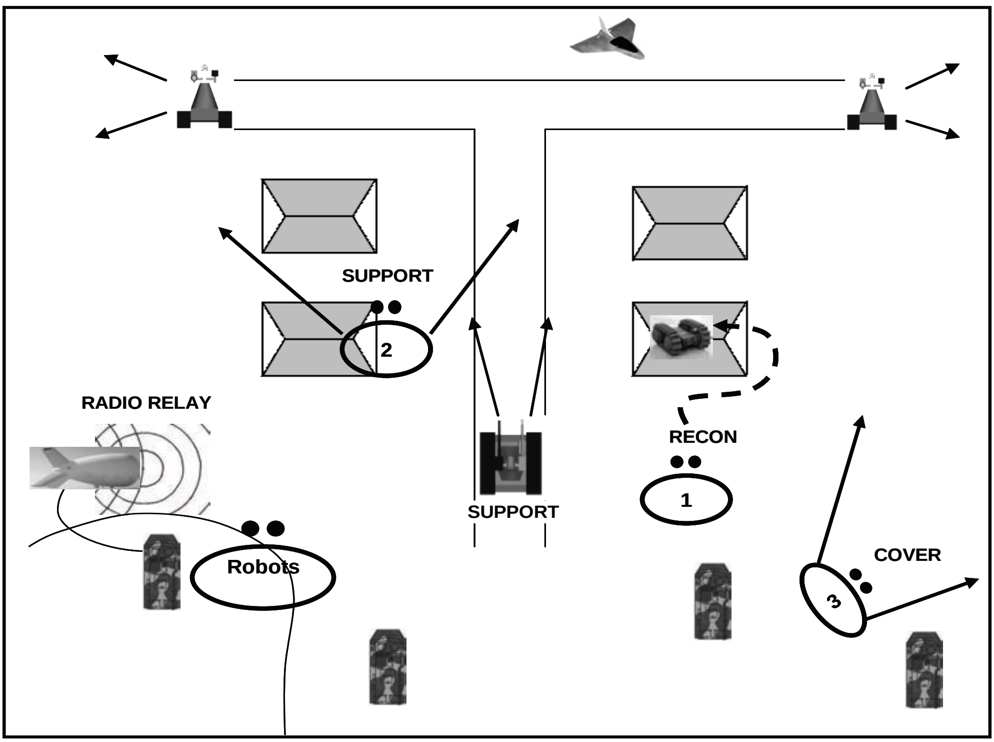

Figure 16. Lieutenant Safetown's Scenario in an Urban Area.

Source: Created by Author.

Lieutenant Safetown launches a radio relay balloon on a high point at the rear of his position. He sends a mini UAV to observe the rooftops of the city. He then deploys two cover robots for observation and a fire support robot to face the primary axis. Afterwards, combat squads are sent, advancing in phase line, and making a reconnaissance of city buildings. Robots are thus used to secure the mission's advance, see Figure 16.

As an entrenched enemy has been identified in a house, a cover robot is sent to that location for combat deception (track vehicle noise, helicopter noise, etc.). Lieutenant Safetown then re-positions a fire support robot closer to the action.

Let's look at Figure 17 to analyze constraints faced by Lieutenant Safetown's platoon and list key ideas:

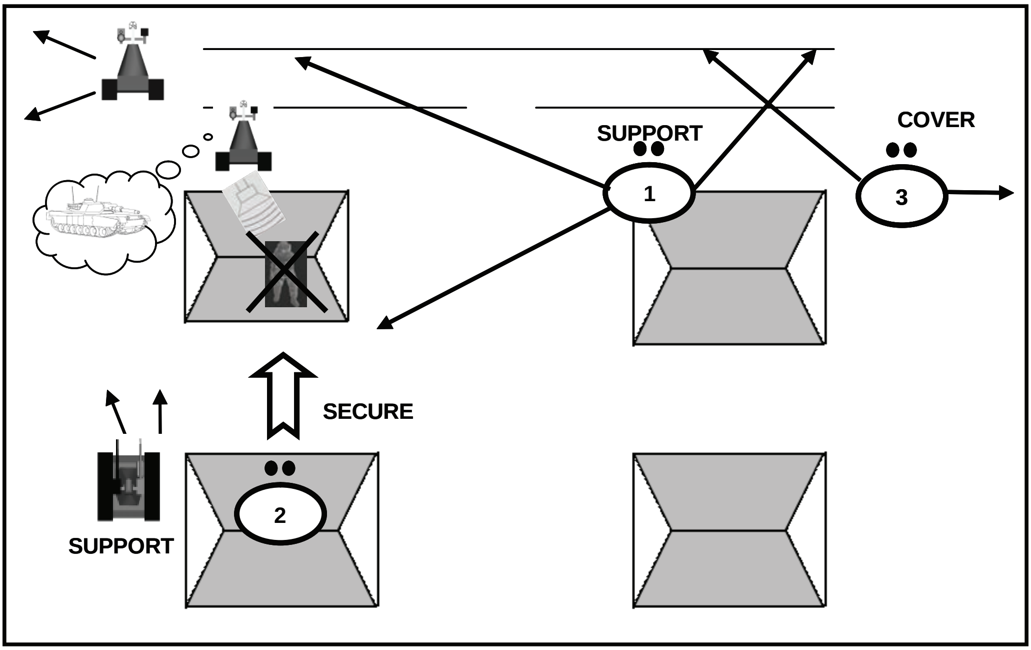

Figure 17. Final Assault Using Robots.
Source: Created by Author.

1. On an organizational level, a decision has to be made at the outset who will be responsible for operating robots in the platoon and who can replace him/her. Robotic systems should be simple to operate as they are managed by soldiers under stress in case of threat.
2. In a combat zone, a soldier is affected by high adrenaline levels and performs basic repeated practices. S/he feels everything but can hardly speak and, above all, it is his/her weapon that assures his/her safety.

Giving orders to robot operators by word is not only complicated but is a major constraint. It also goes against the principle of discretion.

3. The key factor in controlling robots is the design of a communications' protocol in the structure of orders. Such a protocol must be kept simple. Orders must be kept to basics, of the type "Order given and Out."

4. The most appropriate technical solutions for controlling robots have not yet been fully tested. One option is to issue commands via digital weapons as the one used by the French FELIN system for foot-soldiers.[3] As the robot needs to know where it has to perform an action, a control function integrated in the weapon (a laser designator providing targeting) enables an operator to maintain his/her hands on a weapon. Other possible options are headsets with increased reality features as well as brain control (which could be operational by 2030), although he/she should remain fully focused on his/her task, despite the fight. Commanding by gestures is also a possibility as gestures are commonly used by soldiers in groups; they also correspond to basic repetitive acts in combat. Leap motion technology is an interesting example provided that the module can adapt to an operator's movements.[4] A touch screen could be used and placed, for example, on his/her forearm.

Limitations and Constraints in the Use of Robots

We have demonstrated the advantages of using robots and have seen examples of their use on the battlefield. We will now focus on the constraints and limitations in their use. First, there are physical limitations (open field and indoor limitations) which, with current technological constraints (maneuverability, speed, etc.) are barriers for the deployment of robots on the battlefield. Second, engineers should ensure human constraints in combat - and the consequence of conducting battles with robots—have been clearly defined prior to any development. In the heart of a battle, an operator must be able to master his/her robot and not just rely on it. Other examples of general constraints in the use of military robotic systems are given hereafter.

Operational Constraints

In a classic daytime mission, it would be ideal if equipment had between 12 and 24 hours of autonomous power. It is an imperative need to have back-up power during any mission. This can be done in the field if the procedure is simple and, if not, should be planned in advance (changing batteries, automatic charging on platforms, etc.)

The ideal robot is one posing no constraints in its use. It should move at the same pace as the platoon and not be the cause of delays, nor hasten the advance of the platoon. It should move discreetly and avoid identifying friendly devices. During night operations, additional discretion is required and the robot must not be noisy so that it endangers the mission.

The traditional organization of combat units should not be burdened by the use of military robotics, but can be adapted. One could imagine a three party manned combat unit that could be split as follows: a) an infantryman controlling intelligence robots, b) another infantryman controlling support robots, and c) a leader controlling a fire support robot.

Environmental Constraints

Robots should be operational at any time and in all weather conditions (heat, cold, rain, snow, mud). At night, operators should also be capable of grasping a robot's exact position. If UAVs, Unmanned Surface Vehicles (USVs), and Unmanned Underwater Vehicle (UUVs) can operate in a homogeneous and fluid environment, this is not the case with UGVs. They are totally dependent on the nature of the ground for their movements. Physical obstacles humans are able to cross can be impassable for robots as illustrated in Figure 18.

Figure 18. Natural Obstacles.

Source: USDA Forest Service.

The ability to perform jumps or leaps, or even occasionally fly, would solve some of these problems.

Communication Transmission Constraints

Outside recurrent transmission problems (e.g. speed, range, penetration), spectrum sharing should be checked before commencing a mission to ensure communications frequencies are available and unscrambled. As frequencies are shared within Coalition Forces, each unit should ensure the availability of the frequencies used on the battlefield before any movement.

When a unit moves into unknown terrain, military infrastructure has not yet been deployed. The lieutenant should consequently ensure the radio coverage of robots. A mesh network topology could be a solution where each robot acts as a node that can receive, send, and relay data. There is then no need to use centralized communications' relays that can be vulnerable and, depending on the tactical situation, it also enables scalable radio cover.

The bandwidth used on a battlefield is asymmetric between a) the download link (operator to robot), b) the robot to robot link (position, alarms, and optional relays), and c) the upload link (robot to operator) for large data transmissions. Naturally, all forms of latency in executing commands should be avoided for a proper control of robots.

Human Limitations

Such limitations are linked with the physical limits of the soldier. During combat, a soldier's hands should not be hindered by control devices which should be simple to use, not disturbing his/her attention. Data should be kept simple because "too much information kills information" and can distract an operator.

All this reveals the need for a quality recruitment of robot operators. They should be both hardened soldiers and good technicians with a quick mind, to grasp challenging situations.

During combat, platoon leaders rarely use all the capabilities they may have. They need to overcome stress and hence tend to focus their attention on available human resources and accessible equipment rather than the technological resources at their disposal.

Requirements for the Use of Military Robots

In this section, we shall analyze the key requirements for the use of military robots in a combat unit.

Adaptation Phase

An operator should acquire a natural exchange with robots. This will ascertain smooth operations in a combat zone. Each unit should also be informed of the tactical potential and limitations of robots. Prior to combat operations, soldiers will require training to understand how to maneuver with robots in the field. Moreover, as Professor Serge Tisseron has warned, soldiers should have a certain form of aversion in using robots on a battlefield, as they should not endanger their lives to save what are simple tools at their disposal.[5]

Modular Design of Robots

1. A robot cannot match all the needs of land forces. To illustrate: Robots should be configured appropriately for each mission where adaptable modules could be mounted for a more versatile use.
2. Modularity would help in adapting to the terrain and reacting immediately to a given threat. It would contribute to the platoon's reorganization.
3. Robots should be dispatched to other platoons with no sense of ownership. They would be part of a pool of robots serving and supporting all units according to needs. This would significantly decrease costs.

Controlling Robots

In overseas operations, "friendly fire" unfortunately causes collateral damage. Accordingly, it is of utmost importance to control robots when placed in autonomous mode to avoid the risk of casualties. An operator must always have a final say for any lethal decision. A soldier must be accountable for his/her actions in combat and respect the rules of armed conflict (this is not the case of an automatic Counter-Rocket, Artillery, and Mortar [C-RAM] system as its decision-taking time is much faster than that of humans). Similarly, if a robot performs some discrimination in target recognition, it must be controlled by an operator to confirm a target and obviate blunders.

High information exchanges should be managed. With high stress levels, a soldier's attention is low. Data received should therefore be limited when contact has been made, with key data alone transmitted to the soldier (depending on the gravity of the situation).

A soldier should not be technologically dependent on robots. It is therefore important to have the possibility of switching to a downgraded mode whenever necessary. Switching from one mode to another would be practiced during training sessions including examples of mechanical failures (break-down, destruction, no return, etc.).

Cooperating with Other Operators

Future battlefields will be digitized. Military equipment will have communications modules, even with low technology. This is obviously the case with robots and their large numbers on battlefields will require more operators to control them.

An increasing volume of data transiting via networks will need to be structured in such a way that an adequate amount of information is delivered at command level. Specific rules will be established to deliver the right level of information to the correct echelon of command for decisions to be made. Such decisions should not be made at operational command level, leaving lower ranks with no control; for example, the commanding officer should be prevented from taking over the control of a mission under the responsibility of a platoon leader.

It is recommended that robot operators interact with one another on the battlefield and get to know each other for improved coordination. Regular meetings could be held to promote mutual trust amongst them. In this way, endangering friendly dispositions can be avoided and the risk of friendly fire lessened. This will also be done by improving the perception of robotic systems and detecting friendly forces by such systems.

If there is a growing enemy threat to a unit in the field, a specific procedure can be developed for robots to assist friendly forces in close proximity. For instance, the program mode in drones could be modified to allow the vehicles to expeditiously identify a threat or spot an enemy (circle above the enemy unit, for example, or signal by waggling its wings).

Avoiding Compromise

After analyzing world conflicts over the ages, we have learned that we should prevent friendly military equipments from falling into enemy hands. We should therefore prevent an enemy from recovering data from a captured robot. This can be done by:

1. Destroying the robot before its capture by the enemy (remote destruction);
2. Encrypting stored data in the robot (implementing access codes).

It is important to note that embedding voice signature modules in robots, capable of recognizing the voice of their owner(s), may not be a viable solution since robots need to be inter-changeable among units.

Configuring and "Educating" Military Robots

A machine does what it is programmed to do. It should be programmed to be secure and comply with the Rules of Engagement of the Armed Forces. Security rules should therefore be defined for robots. When designing a robot's embedded software, all commands a robot can process and overall events that could occur in the field should be listed. It is then possible to deduct dangerous scenarios from the program, thus avoiding mistakes in software design.

Compliance with the Rules of Engagement should also be analyzed. Every mission and all types of conflict have specific rules. It is the role of the Military Force Doctrine Development Center to define such rules.[6]

1. Rules could be translated into a software language and serve as a safeguard for the execution of orders given to robots.
2. Given the non-human nature of robots, contacts with the population should be avoided in certain missions. It depends on the tension and danger of a mission and also how soldiers are perceived.[7] One can understand such rules differ from the ones in the civilian world. Only military authorities may establish them and robots just have to follow them.

Ethics is the science of thinking and making a decision, on a case by case basis, of what should be done. It is hence the art of solving complicated moral dilemmas according to Thierry Pichevin.[8] If ethical cases are complex for humans, it is difficult to give credence to algorithms being coded in an ethical manner. Writing algorithms with ethical safeguards should nonetheless be considered in the future, more especially for target discrimination. For example, if a robot is unclear in identifying a target (children, civilians, etc.), a protocol confirming the target should be implemented with a human kept in the loop.

Before each mission, robots have to be configured. This is only one aspect in mission preparation which can be secured with a back-up system and a copy of the initial configuration. It will enable a rapid reconfiguration of a blank robot in case of failure or destruction.

In case of loss of contact with a robot, it should be able to return to its home base independently or go into "sleep mode" thus obviating its use by the enemy.

Conclusions

Having listed expected advantages in the use of robots as well as their limitations and constraints, a critical step in the process of supplying military robots still remains: testing.

Robots have to be controlled and tested. Without going into the details of industrial and certification tests, a robot should undergo tests in an operational environment. Furthermore, its announced features should be tested and approved in field conditions.

More importantly, there is also the need for humans to be tested. This would include configuration and reconfiguration tests based on tasks assigned to robots, modularity tests covering the addition and deduction of optional modules, inter-operability tests with robotic systems and handling tests by operators (who must be regular soldiers). Empathy tests could also be included to ensure there is no rejection of the machine by an operator or too emotional a relation with the robot.

Only then can military unit training commence, with robots included in military exercises. In spite of the extraordinary contribution robots may have in protecting fighters, providing tactical advantages and preserving manpower, one should not forget that it is the soldier who is the centerpiece of the military operation - even if his/her actions can sometimes be pushed aside by robots.

Finally, although benefits out-weigh constraints, robots should never be used as an excuse for stopping or cancelling a mission.

Notes

1. Eric Ozanne, “La robotisation du groupement tactiques interarmes” in Didier Danet, Jean-Paul Hanon, and Gérard de Boisboissel (eds.) *La guerre robotisée.* (Economica, 2012), 306-307.

2. Figure 13 inspired by Michel Yakovleff, *Tactique Théorique, (*Economica, 2009).

3. FELIN = *Fantassin à Equipement et Liaisons Intégrés* (integrated equipment and communications for the infantryman) which is similar to the “Land Warrior Integrated Soldier System.”

4. Leap motion : https://www.leapmotion.com/.

5. Serge Tisseron, “Tester l’empathie des combattants pour les robots (TEPR) afin d’eviter les comportements inadaptes au combat” in Didier Danet, Jean-Paul Hanon, and Gérard de Boisboissel (eds.) *La guerre robotisée (*Economica, 2012), 225.

6. Such rules have been defined in France by the *Centre de Doctrine et d’Emploi des Forces* (CDEF).

7. The visual effect of a modern soldier can be quite impressive, even frightening, for civilians. This is called “langage de la tenue” in French (dress language).

8. Thierry Pichevin, “Drones armes et ethique” in Didier Danet, Jean-Paul Hanon, and Gérard de Boisboissel (eds.) *La Guerre robotisée,* (Economica, 2012), 235.

Chapter 19
Is the Insect the Future of Robots?
by Alexandr Štefek

Introduction

At the current stage of robot development we are forcing technology toward a reliable design. The need is not always achievable. As a good example, imagine a situation in which the operator or user has connection with a robot via wireless communication. Especially in buildings area robots can easily lose this connection. One of the possible solutions is to use autonomy for finding a new place where the connection is established. But is it not possible to use other robots in same area to retranslate the signal? Robots under control of the same master will use the same type of communication.

Robots are used in reconnaissance tasks and if those robots are smaller they will have a higher probability of success in avoiding enemy sensors. It is really hard to build small reliable robot. But it is possible to build a set/swarm of robots which will try to solve same problem. Losing one robot from a small swarm will be noticeable but still the task can be finished. Even without any cooperation the swarm has higher reliability and we can expect better results. Let's imagine that those robots cooperate. They can help each other to reach the overall goal.

The swarm approach is applicable in many military areas. There exist small low cost sensors which can be spread across a wide area to cover passages or other critical sections and secure them against enemy disruption. A single sensor is not able to do anything but in cooperation with other sensors it is able to detect disrupting and send this information to the consumer/observer. Sensors together create a net with an ability to interchange information with a neighbor. In fact this net behaves like single entity with high performance in the sensing task.

Even if we are still not able to create useful small cooperating robots, we can use natural inspiration to solve some problems which are unsolvable by deterministic methods. One of the main problems with which we are in touch nearly every day is the optimization problem. Optimization is a process where solutions are examined and compared together so it is possible to put one (optimal) solution above others. Methods which are inspired by insect behavior are general and very powerful. To this set of methods belong the Particle Swarm Optimization method (PSO), and the Gravity Search Algorithm (GSA), variations and improvements, and many others. If we will be able to take those methods into the real world we will notice stochastic behavior of many entities but the swarm will approach the desired solution.

First Look at the Current State of Robot Development

It is common to develop a single robot entity with all needed capabilities, tools, and equipment. This robot has to reach a goal at any cost and return to its base to give gained material, rescued items, captured data, and information. When one part of robot fails or is destroyed by enemy entities, it is possible that the robot will not be able to attain the desired goal and the whole mission will fail.

A single entity type robot which was developed according to inspirations by man's abilities will not be able to reach the goal. This leads to the process in which we want to develop a better robot with greater robustness with many spare subsystems which are able to replace malfunctioning or destroyed subsystems. This new robot would have a higher chance to reach the desired goal. But the development of these robots is very demanding. It is not easy to analyze all subsystem linkages and evaluate them to recognize which subsystems have been duplicated to reach the desired reliability.

Limited Subsystems

In Nature, limited functionality is pretty common. Recall the battle of Stalingrad during the Second World War where the Russian side did not have enough weapons. Soviet commanders created units in which two soldiers carried just one weapon. When one man died or was not able to use weapon due to injury, the second man was commanded to take up the weapon and shoot with it.

Let's have a look at ants—they cooperate in an effort to pull food to the ant hill or when they are defending their home, Figure 19. Insect groups consist of members with different abilities. Well known is the situation in the anthill. There exist warriors, workers, and the queen. Isolation of one type will create group of ants which is not able to survive.

Cooperation is very common in other social groups, Figure 20. For example, grey wolves hunt in packs. A lone wolf cannot slay bison or deer but together they are able to hunt much bigger animals. In this case the synergy effect occurs.

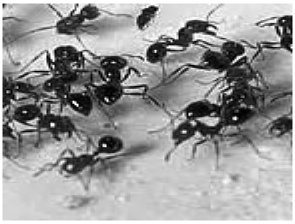

Figure 19. Cooperating Ants.
Source: US Department of Agriculture website.

Figure 20. Cooperating Wolves (Canus Lupus).
Source: National Park Service, US Department of the Interior website.

In those groups, if one element is destroyed or injured, the rest will remain active and will try to reach the assigned goal with a high chance of success.

Cooperation is very important in human society as well.

In fact an army is a highly organized social structure. Each part of army (squad, platoon, company) consists of a set of soldiers. When one soldier is injured, the remaining soldiers take over his task and continue to fulfilling the command's mission.

Figure 21. Army Unit on Patrol.
Source: US Army website.

Levels of Cooperation

Cooperation has different levels. It is possible to identify three basic levels:

1. Cooperative Thinking
2. Cooperative Sensing
3. Cooperative Acting

The most common level of cooperation is cooperative thinking. This is widely used in many applications. Cooperative acting is not common in real applications. Only social and natural groups cooperate in actions.

Cooperative Thinking

Cooperative thinking is used in information processing. The common accepted term for this is a multi-agent system.

Multi-agent systems (MAS)

Multi-agent systems are systems in which many items are acting. Those items (subsystems) can use the same algorithms for behavior or they can have different roles. The important part of multi-agent systems is the communication subsystem.

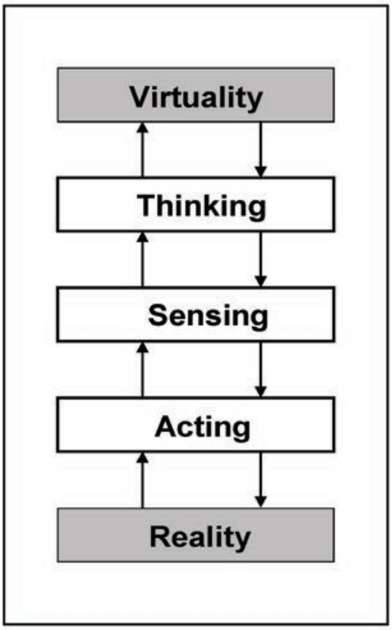

Figure 22. Relations in Applications.

Source: Created by Author.

Top—"Virtuality"—describes applications in computers. Bottom—"Reality"—represents work with real things.

Multi-agent systems are theoretical tools that have been used widely for a long time.

The characteristics of MASs are that:[1]

1. Each agent has incomplete information or capabilities for solving the problem and, thus, has a limited viewpoint;
2. There is no system global control;
3. Data are decentralized;
4. Computation is asynchronous;

The Computer Science Point of View

Cooperative thinking is a process of sharing computing resources. The task is running somewhere in the system even on robots which are not using the results of the computation. Moreover for increasing robustness, the process can be copied across robot groups. If one robot fails or is disconnected from the group, there are still copy processes which enable the rest to finish the computation. In the phase of disconnection identification there is a need for recovery, to make a new copy of the processes which were running on the lost robot. Because the copies are still running, the copy process is feasible.

This backup increases robustness and reliability. The basic principles of concurrent processes are well known and discussed in computer science, specifically in the concept of in cloud computing.

Cloud Computing

Cloud computing has some approaches which are identical to cooperative thinking. If the thinking process is divided into many threads, they are executed in parallel. In fact it does not matter where the threads are executed as long threads can access all the requested information.

The division of thinking into threads allows multiple executing threads. This grants an ability to continue in execution even if one thread fails. The reasons for failure can be different. If the computing environment is bordered by cooperating robots, then each thread is executed on more than one robot. If a robot is destroyed by enemy activity (in a military environment) or a hostile environment, there still exists a copy of the process which was executed by the destroyed robot.

Runtime Compilation and Execution

Runtime compilation is a technique widely used in the process of expression evaluation. With introduction of JAVA language this technique becomes a foundation for program development. The .NET environment (Microsoft technology) uses nearly the same principles.

Runtime compilation allows for the compilation of parts of code or whole libraries into executable form and executing them. There are two levels of compilation. The higher level compiles source code into Common Language runtime (CLR) and the lower compiles into the native code of the current processor. Two levels of compilation allow the developing processor an independent code. It is possible to develop an environment which will provide a standard set of services on each robot platform. This will offer environments for task execution on all robots. Moreover the running task will be isolated from platform.

There is an important question at this point. What is the difference between runtime compilation and execution and "standard approach" where all programs are stored on all devices/robots? This is a hard question to answer. Imagine that some knowledge is stored as algorithms which can mutate.

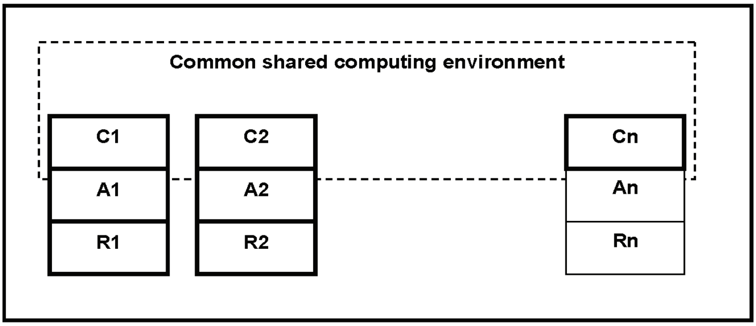

Figure 23. Shared Computing Environment.
Source: Created by Author.

See Figure 23. R1 (R2,...Rn)—robot level, this level can vary. A1 (A2,...An)—abstract level, this level grants standard abilities for level C1 (C2,...Cn). C levels are same on all robots.

Runtime Compilation and Execution—Technological Background

Runtime compilation is technology which can serve in program modification during program execution. This technology was developed and supported on many platforms. One of them is .NET platform. Code 1, Figure 24, shows the basic structure for runtime compilation on the .NET platform.

```
CSharpCodeProvider codeProvider = new CSharpCodeProvider();
CompilerParameters cp = new CompilerParameters();
cp.ReferencedAssemblies.Add("system.dll");
cp.ReferencedAssemblies.Add("RoboticSystemEvironment.dll");
cp.GenerateExecutable = false;
cp.GenerateInMemory = true;
string code = CreateClassSourceCode(vars, function, constrains);
CompilerResults cr = codeProvider.CompileAssemblyFromSource(cp, code);
if (cr.Errors.HasErrors)
{
    StringBuilder error = new StringBuilder();
    error.Append("Error Compiling Expression: ");
    foreach (CompilerError err in cr.Errors)
    {
        error.AppendFormat("{0}\n", err.ErrorText);
    }
    throw new Exception("Error Compiling Expression: " + error.ToString());
}
Assembly a = cr.CompiledAssembly;
Object _Compiled = a.CreateInstance("OpenRoboticSystem.Task._CompiledTask");
SetTask(_Compiled as ITask);
```

Figure 24. Code 1: Runtime Compilation.

Source: Created by Author.

Adaptive Algorithms

Some problems can be solved by different algorithms. Choosing the right algorithm can be a problem, the solution of which is not easily predictable. One published paper describes examples in which the decision was random. The impact of the algorithm was evaluated and the next behavior was adapted to the last set of experiences.

Adaptive algorithms/adaptive behavior can be used on a problem to find an optimal path. This problem is already solved, but it can be generalized to a problem where the destination point is moving.

Let's imagine comparable algorithms for choosing the right direction on a crossroads. Different algorithms have different impact on ability to find the best path from a start point to a destination point, but all of them are able to choose a path. Figure 25 describes the decision situation. The agent at node A has to decide where to move (nodes B, C, D). Every path has an associated fitness value. This value varies in time and evaluates the intensity of usage. At decision time, the agent does not know which path is optimal. Because the paths were evaluated by other agents, there are 4 possible algorithms for selection.

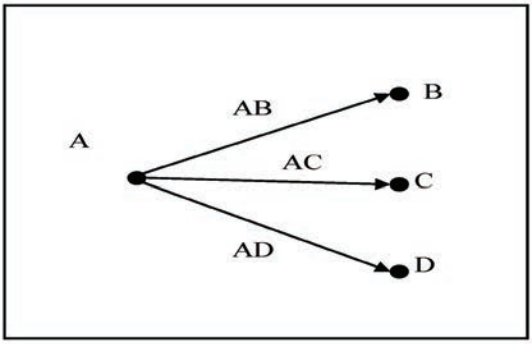

Figure 25. Decision at Node.
Source: Created by Author.

Mentioned algorithms for selection are:

1. Choose best path (ChooseBestEdge).
2. Choose path randomly without any weight (ChooseRandomEdge).
3. Choose path weighted randomly (WeightChooseRandomEdge).
4. Choose shortest path (ChooseEdgeOnShortestPath).

At node A the agent will choose the algorithm for decision (from enlisted algorithms according to random number). Then it uses the selection decision algorithm. At node B the agent will again choose the algorithm and use it for the decision. This behavior has adequate terms in game theory (pure and mixed theory).

When an agent reaches a goal and if its path is one of best, this set of algorithms is stored in the genetic bank.

In our example above, when the process of cooperative thinking was started, the probabilities were set to:

`ChooseBestEdge` 5/20, `ChooseRandomEdge` 5/20, `WeightChooseRandomEdge` 5/20, `ChooseEdgeOnShortestPath` 5/20.

In the early stages, the probabilities in one of sets of algorithms are:

`ChooseBestEdge` 5/20, `ChooseRandomEdge` 8/20, `WeightChooseRandomEdge` 4/20 `ChooseEdgeOnShortestPath` 3/20.

In the middle of the process, the sets will adapt so one of them has the following probabilities:

`ChooseBestEdge` 6/20, `ChooseRandomEdge` 3/20, `WeightChooseRandomEdge` 4/20, `ChooseEdgeOnShortestPath` 7/20.

And finally at the end:

`ChooseBestEdge` 7/20, `ChooseRandomEdge` 0/20, `WeightChooseRandomEdge` 5/20 `ChooseEdgeOnShortestPath` 8/20.

The behavior was adapted to fill the desired role.

Cooperative Thinking—Solving Optimization problem

As an example of cooperative thinking, an optimization problem and its solution was chosen. This decision was made as a result of natural entities modelling. In nature (as mentioned earlier) there exists many groups/flocks/herds/swarms which optimize in an effort to survive. From some points of view, there are methods which use an analogy from this behavior.

Currently there is enough computer performance for Monte Carlo-based methods of creating computational algorithms. Just roll the dice, do some statistical calculations and the results will appear. Of course a stochastic approach does not grant the optimal solution. But there are many problems which are not solvable by deterministic algorithms. In those cases the suboptimal solution is acceptable.

The next paragraphs will introduce some methods in which the collaboration leads to practical results.

Particle Swarm Optimization (PSO) Method

The PSO method uses the behavior of a flock of birds as a model. Each bird is flying through space (set/space of solutions) searching for food and sensing "food intensity." A bird remembers the place with best intensity and when a better place (with higher intensity) is revealed the best place is updated and information about this location is spread across the flock. A bird is flying randomly but tends to return to a personal best position (solution) and travels to a best position discovered by the flock.

This model of behavior was first implemented by J. Kennedy and R. Eberhart.[2] This implementation is very popular currently and has been greatly improved. Let's first show the mathematical model of PSO.

The mathematical model uses motion of law from physics. See Equation 1 in Figure 26.

$$x_{n+1} = x_n + v_n$$
$$v_{n+1} = c_0 v_n + c_1 r(x_l - x_n) + c_2 r(x_s - x_n)$$

Figure 26. Equation 1.

Source: Created by Author.

Where x_l is the best solution for particle and x_s is the best solution for whole swarm, c_i are setup coefficients, r represents random numbers from interval (0;1), x_n, v_n define current state of particle and x_{n+1}, v_{n+1} define the next state of particle.

In the process of space exploration the particles tends to return back to the best known position (solution) and tend to visit the best known swarm solution. This process is controlled by coefficients c_1 and c_2. Coefficient c_0 defines the slowing speed. In fact, these equations define (in general) the unstable system. The c_0 coefficient plays the role of stabilizer. If this coefficient is $c_0 \geq 1$ then the kinetic energy in the system is growing infinitely and this means that the system is unstable and cannot produce the desired solution.

The social aspect of this model was studied deeply by a group of scholars.[3]

As mentioned above, this model is very popular even if it has some real problems. The main problem is a particle stuck in local optimum. The method is unable to leave this "hole." This problem was solved by Repulsive PSO (RPSO). RPSO uses some random solutions. According to RPSO the equation was updated to:

$$x_{n+1} = x_n + v_n$$
$$v_{n+1} = c_0 v_n + c_1 r(x_l - x_n) + c_2 r(x_s - x_n) + c_3 r(x_r - x_n)$$

Figure 27. Equation 2.
Source: Created by Author.

Where x_l is the best solution for the particle and x_s is the best solution for the whole swarm x_r is a random solution, c_i are setup coefficients, r represents random numbers from interval (0;1), x_n, v_n define current state of particle and x_{n+1}, v_{n+1} define the next state of the particle.

GSA—The Gravity Search Algorithm

The gravity search algorithm uses similarity with gravitational fields in the universe. Bigger planes generate a gravity field with greater intensity.

$$F_{ij} = G \frac{M_i M_j}{R} (x_i - x_j)$$
$$F_i = \sum_{\forall j} F_{ij}$$

Figure 28. Equation 3.
Source: Created by Author.

Where G is a substitution of the gravity constant, M_i, M_j are particle masses, x_i and x_j are particle positions, and F_{ij} and F_i are forces. The mass of particles (planets) is weighted by the value of the fitness function at point where the planet is. The masses are normalized. The normalization of mass is based on the fitness function value. The particle with better fitness function value has a bigger mass. The normalization process is described in Figure 29, Equation 4.

$$m_i = \frac{(f(x_i) - min)}{(max - min)}$$

$$min = min\{f(x_1), f(x_2), \cdots, f(x_n)\}$$

$$max = max\{f(x_1), f(x_2), \cdots, f(x_n)\}$$

$$M_i = \frac{m_i}{\sum m_i}$$

Figure 29. Equation 4.

Source: Created by Author.

Where *min* is the current minimum of the fitness function, *max* is the current maximum of fitness function, m_i are masses and M_i are normalized masses. The gravity coefficient is not constant and varies in time according to the equation in Figure 30, Equation 5.

$$G = G_0 e^{a(t)}$$

Figure 30. Equation 5.

Source: Created by Author.

Where G_0 is the base gravity constant, *a(t)* can be a function but usually it is constant, *G* is a gravity constant for current state of optimization process.

In the optimization process the set of particles which are acting as a gravity source (according to Equation 2 in Figure 27) is decreasing. This process reduces the ability to find a better solution as time goes on.

Conclusion

All methods use a set agent which is moving, sensing the current stage and exchanging the discoveries. This process is made on low level for individual particles but in fact this can be done with agents representing methods itself. There are some studies about topology of agent communication in which experiments prove that complete connection does not behave well in optimization problems where the fitness function has local optimums. The communication restriction to a neighbor inflicts situations in which not all agents know the current best solution. This allows agents to stay a bit longer in a place in order to better explore it. In the original model, agents are slowly moving towards the new best solution immediately after recovering. As mentioned above, this leads to being stuck in a local optimum, which was enough strong to pull all agents into a "hole."

The same principles are usable in method cooperation.

Cooperative Sensing

Cooperative sensing is a useful ability which grants access to all robots in one group to whole set of sensors carried by different robots. In fact it allows complete information of a wide area where the set of robots are trying to finish a task.

This ability can be used in commanding the robot group. A common problem is the loss of the connection with one single entity/robot. Especially in buildings during rescue or reconnaissance operations, this is a very common situation due to signal propagation. In a situation where robots are using hex networks, they are able to retranslate a signal and allow commands to robots which are unreachable.

A typical situation is depicted in Figure 31.

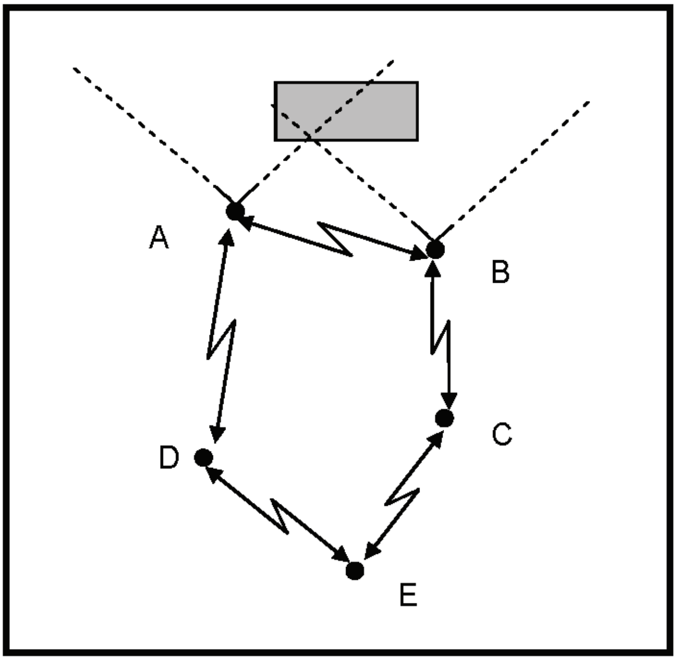

Figure 31. Cooperative Sensing—Sharing the Sensor Information.

Source: Created by Author.

The units in front of group (A and B) are sensing the obstacle/enemy from different views. Sensed information is distributed across group and rear unit (E) is able to get and process it.

The individuals in the group can act as sources of sensor information and as re-translators. This functionality combination allows the creation of ad hoc sensor nets and the gathering of sensor information from any node set. The communication and other aspects have been discussed.[4]

Some applications using cooperative sensing are already in use, especially in the defense of important objects and areas. There are sets of sonic sensors with a fusion algorithm which helps in shooter localization. The precision of localization is very good.

Cooperative Navigation

Cooperative navigation takes advantage of image processing of pictures where some objects are well known. This means that dimensions can be taken into account and the distance and orientation can be computed. With the fusion of other types of sensors (ultrasonic, infrared, laser), this can be used in precise navigation. Part of a group is moving and the rest of group is playing role of a steady base. Fixed units are able to measure the movements of other units. Practical experiments with this approach have been conducted and results published.[5]

Figure 32, Equation 6 describes the projection of a real object at an image sensor. If the size and resolution (S) of the image sensor is known, then it is possible to compute the distance to object A.

$$\frac{d}{f} = \frac{l}{o}$$

$$d = f\frac{l}{o}$$

Figure 32. Equation 6.

Source: Created by Author.

Where d is the distance to object A (millimeters), f is focus length (millimeters), o is the real size of object A's projection on the optical sensor (millimeters). It is possible to compute o according to Figure 33, Equation 7:

$$\frac{o}{o_p} = \frac{s}{s_r}$$

$$o = o_p\frac{s}{s_r}$$

Figure 33. Equation 7.

Source: Created by Author.

Where o is real size of object A's projection on an optical sensor (millimeters), o_p is length of object A in a picture (in pixels), s is real size of sensor (millimeters) and s_r is sensor resolution (in pixels).

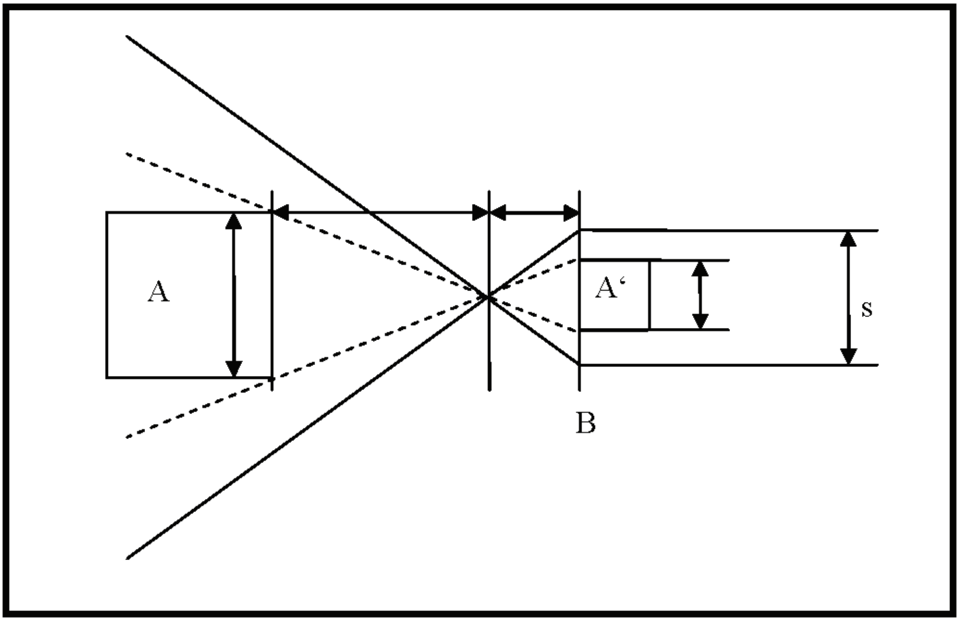

Figure 34. Cooperative Navigation - Using the VideoSensor for Distance Recognition.

Source: Created by Author.

The equations and Figure 34 can be generalized and used for computing the orientation and till (two dimension) of object A. This leads to a system construction where one object does not move during the moves of the observed object. This observation helps in increasing the precision of the navigation process.

Cooperative Acting

Cooperative acting is really an old idea. Just recall the science fiction movie and television series *StarGate* in which humans are fighting replicators. Replicators share the sensor information, are able to create new copies of themselves, are able to join together and create a much bigger entity if needed. Those abilities make them very powerful and very difficult to destroy. Imagine that it is possible to have same the type of entities under command on the battlefield.

Unfortunately (or fortunately), this is just science fiction which may become reality in the distant future. But the current state of the art shows some achievements. Projects already exist in which scientists are working on the ability to join single entities into a bigger group to be able reach more complicated goals. Two practical goals are set as the group objectives—crossing obstacles and pulling objects.

Crossing Obstacles

In reality, there will always be objects and obstacles that are too big in relation to the robot. There exist two possible solutions—the robot avoids the obstacle and the robot crosses the obstacle. If the robot is "big enough" for crossing, the problem has an easy solution. In the case where the robot is too small there still exists the possibility (in some designs) to connect more robots to create bigger one with the ability to cross the obstacle.

This approach has been tested by some scientists with great success.

Pulling Objects

In some cases robots are asked to make an effort to change the physical world. This is especially important in a rescue mission. If the goal is to rescue a man, it is possible to build robot which is big and powerful enough. The connection of many small robots in filling the rescue task will be a general solution to the problem of building adequate size and power.

Connecting many robots to make one entity to improve the ability to pull an object has already been tested. One of those tests was executed in project Swarm-bots.

Swarmanoid Project

The Marco Dorigo Swarmanoid project which developed the concept of swarm-bots, swarms of self-assembling entities which is one of the most important projects in the study of robot cooperation.[6] This project was conducted by five research institutes.[7]

The project ran from 10 January 2006 to 30 October 2010 and was supported by The European Commission. It was focused on building robots that can successfully and adaptively act in human-made environments. The project is the first which studied how to design, realize, and control a heterogeneous swarm robotic system capable of operating in a fully 3-dimensional environment.[8]

Conclusion

Cooperation is common in nature, and important in human society. Many animals, insects create structured groups. Different members have different abilities. In recent years, significant effort has been invested in experiments with cooperating robots. Those experiments were successful in many aspects and have great potential for future implementation. Especially in the military area there exist many tasks for which this concept will be very helpful. But still there are gaps which have to be filled, and questions which have to be answered.

Notes

1. Katia P. Sycara, "Multiagent Systems" *AI Magazine* Volume 19, No.2 Summer1998: 79-92, http://www.cs.cmu.edu/~softagents/papers/multiagentsystems.pdf, (accessed 5 November 2013).

2. James Kennedy and Russell Eberhart. "Particle swarm optimization." In *Proceedings of IEEE International Conference on Neural Networks,* IEEE Press, 1995, 1942-1948.

3. James Kennedy and Russell Eberhart, *Swarm Intelligence.* Morgan Kaufmann, 2001.

4. Jaroslav Cechak, "Seismic Sensor Communication" in *Advances in Military Technology* Vol. 5 No. 2, 2010: 101-108, http://aimt.unob.cz/articles/10_02/10_02%20(9).pdf, (accessed 5 November 2013).

5. Yves Bergeon, "Calculation of the distance covered by a robot thanks to image analysis with a two-robot team," in *Proceedings of the 2011 ICMT Conference,* 2011.

6. Marco Dorigo et al. *Swarmanoid: Towards Humanoid Robotic Swarms,* http://www.swarmanoid.com/index.php, (accessed 5 November 2013). Marco Dorigo et al. *Swarm-bots: Swarms of self-assembling artifacts,* http://www.swarm-bots.org/, (accessed 5 November 2013).

7. IRIDIA—Institut de Recherches Interdisciplinaires et de Développements en Intelligence Artificielle—Université Libre de Bruxelles (Belgium); IDSIA—Istituto Dalle Molle di Studi sull'Intelligenza Artificiale (Switzerland); EPFL-LSRO—Institut de Production et Robotique—Laboratoire de systèmes robotiques (Switzerland); EPFL-LIS—Laboratory of Intelligent Systems—École Polytechnique Fédérale de Lausanne (Switzerland); CNR-ISTC—Consiglio Nazionale delle Ricerche Institute of Cognitive Science and Technology (Italy)

8. Marco Dorigo et al. *Swarmanoid: Towards Humanoid Robotic Swarms.*

Additional References

E. Rashedi, H. Nezamabadi-pour, S. Saryazdi. "GSA: A Gravitational Search Algorithm" in *Information Sciences* Vol. 179 No. 13, 2009: 2232-2248.

Z. Krupka, A. Stefek, "Method Cooperation in Optimization Process" in *Proceedings of Mechatronika 2010 Conference:* 21-23.

Z. Krupka, A. Stefek, "Particle Swarm Optimization—Experiments and Results" in *Proceedings of Advances in Mechatronics* 2009 Conference.

Chapter 20
Robotization of the Combined Arms Task Force: Perspectives
by Eric Ozanne

Introduction

The first robotized ground systems were used during World War II. After this conflict, the perspective of a conventional confrontation in central Europe between the Western countries and the Soviet bloc, like the decolonization conflicts, did not help develop a capacity which was still in its infancy in 1945. Recent conflicts (Iraq, Afghanistan, Middle East) combined with the significant technological progress over the last years have been favorable to the rapid development of these systems. This framework was all the more favorable since ground robots seem to immediately bring solutions to western armed forces belonging to societies the resilience capacity of which is weakening and which less and less accept casualties in combat, whatever the stake of the conflict.

The French Army, supported by the Procurement Agency (DGA), has carried out conceptual and technical studies in the 1980s, then deeper ones during the first decade of the 21st century. Some robotized systems have been created and are still fielded in the forces, like the AMX30B2, the remotely operated mine-clearing tank.

This research conducted by the Army has recently been relaunched within the framework of the second step of the SCORPION[1] armament program and were first materialized in 2011 with the drafting of an exploratory project on ground robotics made by the Army Staff/Plans, followed by a staff objective[2] on the robotization of the combined arms task force.

This assessment of the Army requirement and these conceptual reflections in a short/medium-term vision are just a first step in the robotization of the land forces, both in terms of ambition and scope, since they are limited to the combined arms task force. The research is thus continuing, the reflection being extended to all the forces and other concepts of employment of robotized systems are being envisaged.

Overall Framework and Concept

Overall Framework of the Research

The studies have been carried out in 2011 in the framework of a working group preparing the second step of operation SCORPION.[3] They were based on all the research conducted over the last ten years, including those led by the Centre de Recherche des ecoles St-Cyr Coëtquidan (CREC), and have been carried out in coherence with the ground robotics exploratory concept of the Army Staff. The research is limited to the ground and air assets of contact robotics meeting the specific needs of the combined arms task force and aimed at being implemented by non-specialized units.

Disclaimer: The views and opinions expressed in this article are those of the author and do not necessarily reflect the views or opinions of the French MoD.

The Operational Environment by 2025

The expression of a new military requirement is partly based on the possibilities offered by technology by the considered timeline. Nonetheless, this requirement must first and foremost meet identified threats with which the Army could be confronted in the framework of its operational contacts. The concepts of employment and technical specifications of these future items of equipment thus result from these threats.

Identifying future threats is indisputably a more difficult exercise today than it used to be. Without depriving some great military thinkers of the 20th century of their visionary talent, it was easier to envisage a revolutionary employment for the main battle tank in the 1930s or for the nuclear weapon in the 1960s given the geostrategic context and the existence of a clearly identified adversary whose courses of actions and capabilities were well known, than to imagine the employment of robotized systems today.

The future operational engagement can however be characterized by an atmosphere of uncertainty and unpredictability, with very variable levels of confrontation. The emergence of asymmetrical situations will remain very high without ruling out a comeback of, if not symmetrical, at least dissymmetrical confrontations. The theaters of engagement should be extended while actions among populations in urban terrain will become the rule, as well as the multiplication of stakeholders within the theaters of operations. The easy access to new technologies and the increasing place of psychological effects (especially cyberspace) will be determining characteristics in order to conceive the robotization of the land force. Lastly, this future operational environment will certainly be characterized by strong constraints induced by our societies themselves: a budgetary constraint which implies that we remain reasonable regarding the design of equipment, a statutory and environmental constraint which is of paramount importance in the specifications of military equipment, as well as societal constraints which place a value on human life which is increasingly incompatible with the risks of the military profession.

The research and reflections conducted in view of combined arms task force robotization must indeed be placed in the perspective of this future envisaged operational context.

Concept

The robotization of the combined arms task force, and more generally that of the land forces is not an end in itself. Robotized systems support ground maneuver in which man keeps his entire place, and they deliver an effect in the field on the adversary or for the benefit of the force. Fully integrated into SCORPION, they participate in the fulfilment of all the missions of the combined arms task force. These robotized systems do not have decision-making autonomy and the principle of "man in the loop" is required.

Combat Robotization Meets Three Objectives:[4]

1. *The first objective is to improve the protection of the soldier by limiting his/her exposure to battlefield dangers.* The objective is not to replace men by robots in combat, but to preserve the potential of the combatants or of major items of equipment by permitting them to deploy in the best possible conditions.

2. *The second objective is to increase the combatant's capacities and therefore the operational efficiency of units.* Indeed, the combatant's efficiency is limited both by the tolerance of man for his environment (heat, humidity, CBRN threat, night, etc.) or his physical capacities (height, volume, weight, mobility, etc.), and by his own senses or "sensors," even if he can be equipped with efficient perception assets. The robotization of contact should thus extend the operational capabilities of the combined arms task forces, in terms of rapidity and accuracy of fire, and in terms of quantitative and qualitative improvements of communication tools as well as reconnaissance and acquisition assets.
3. *The last objective is to permit the fulfilment of repetitive and dull tasks.* The efficiency of a robot, adapted to a given environment and predefined tasks, is highly superior to that of men. The robot can perform its mission for extended periods of time and is perfectly regular in its fulfilment. Besides, robotics would make it possible to lighten the burden of the soldier in some physical security or logistic support tasks.

Tactical Priorities

A comprehensive study of "robotizable" actions over the entire spectrum of missions of the combined arms task force has been carried out. These actions have then been prioritized and cross-checked with the technological maturity of the various systems. The defined tactical priorities are going to guide the equipment policy of the forces for the coming years. The robotization of contact must thus be in priority:

1. *Enhance the capabilities of the combined arms task force in the field of contact intelligence.* Battlefield digitization has made it possible to disperse some of the fog of war by providing in due time a true, precise, and shared situational picture. Robotized assets should thus contribute to further disperse this fog by providing this time a better vision of the enemy situation in contact. This awareness of the tactical situation down to the lowest echelons will enable the combat units to engage as late as possible in the best possible conditions.
2. *Improve the capacity to detect, identify, neutralize, and destroy the mine and explosive ordnance threat if need be.* It is in this single domain that the Army has had robotized systems for many years. The objective is to reinforce the destruction and neutralization capabilities of the existing systems while limiting physical human intervention as far as possible.
3. *Complement the destruction capabilities of the combined arms task force (fire delivery, armament implementation).* This intentional third priority leaves the door open to research and reflections on armed robots, the implementation of which provokes at once ethical and

legal questions. These armed or shooter robots would first be aimed at applying effects in the field (breach a wall, clear a barricade, etc.) before envisaging a larger employment.

4. *Participate in forward logistics (lightening/supplying combatants in contact).* Though the individual logistic overload has been a permanent feature in the history of the infantryman since the Greek phalanxes, it has considerably increased over the last ten years, due to the "come back of [personal] armor," the variety of armaments, ammunition consumption, and new technologies. This logistic burden currently reaches more or less 50 kilos for each dismounted combatant (the historic average was between 35 and 40 kilos), and even more, depending on the operational employments (machine gunner, mortar loader, etc.). Robotized systems will undoubtedly bring solutions to this issue, be they MULE robots or exoskeleton-types. Since the latter are not robots as such, they are not dealt with in the contact robotization operation of SCORPION, but they are taken into account within the framework of the research and reflections on the evolutions of the FELIN system.

Meeting the Need

Envisaged Systems

What characterizes robotized systems is their diversity and distribution within the combined arms task force. These systems should first equip the "dismounted combat," "mounted combat," and "battlespace exploitation" operational functions.

Two components have been defined as well as a classification of robots by weight. This segmentation is not rigid and is just a first attempt to characterize the systems. Their implementation complexity, their functional autonomy and range of action increase, ranging from the micro-robot/micro UAV to the heavy tactical robot. In all cases, these robotized systems do not have any decision-making autonomy and man always remains in the loop. Moreover, these capabilities make up a more or less comprehensive list of the robotized systems which could equip a combined arms task force by step 2 of SCORPION; some assets could seem redundant (puppet-type systems and tactical or heavy robots). Choices in terms of equipment policy will be made in due time.

The combined arms task force would first have a dismounted component including:

1. *Micro-robots* (maximum 5kgs) implemented by single operators who can easily transport them on a long-lasting basis. These systems are actually the "off-site eyes" of the infantryman or the dismounted combatant. Their employment has to be prioritized for inside a building or subterranean networks in order to carry out contact intelligence missions (observe inside a building, a subterranean network, a pipe, a room or a corridor before entering into them). Equipped with a camera, their range of action is limited to a hundred meters and a PALM-type control station also permits receiving of images. Easy

to implement and robust, they can be launched by a soldier (on the floor of a building, in a stairwell, etc.). This type of robot has been regularly used for twenty years or so by some specialized units in the French security forces. They are also fielded in some foreign forces (especially the US Army) in theaters of operations (Afghanistan, Iraq). They should equip the infantry and engineer platoons down to group [squad] level.

2. *Minirobots* (maximum 50 kgs) usually transported in the vehicles of the combined arms task force, they can be carried over a short distance by one or two personnel, and can be equipped with several payloads. These systems will be the "off-site eyes and tools" of the dismounted combatant. Used outside buildings, their employment in urban terrain will nonetheless be prioritized. With a range of several hundred meters, they will carry out contact intelligence missions (scout the advance of a platoon in urban terrain, detect targeted optics, lay sensors, etc.), will be able to deliver effects in the field (process a booby-trap, breach a wall, or clear a barricade, etc.) or on the opponent (generate a smoke screen, etc.). Robust and easy to implement, they will have some functional autonomy. These systems should equip the infantry and engineer units down to platoon level. These minirobots could also participate in the surveillance and protection of the sites used by the forces.
3. *Micro-UAVs* (one or two kilos), equipped with a camera, easy to implement, able to be easily carried by a man, these systems will constitute the "flying binoculars" of the platoon leader or unit commander. With a range of one to two kilometers, which corresponds to the operational need of dismounted units in contact, they will permit to see behind the wall, the building. or the surrounding terrain.

The combined arms task force could also be equipped with a dismounted component comprising:[5]

1. *Micro-UAVs* which would be more efficient than those of the mounted component. These systems would have a wider range (4-5 kms) and could be fielded for the scout units of the mounted combat operational function and the infantry regimental reconnaissance platoons. These systems will have to be able to be implemented from inside the vehicles in order not to slow down the maneuver tempo.
2. Versatile tactical robots, which are more complex systems, characterized by a high level of functional autonomy and the ability to meet a wider spectrum of missions owing to their capacity to carry varied payloads. Their mobility would enable them to integrate and follow the infantry and armored mounted maneuver of the combined arms task force. The versatile tactical robots could carry out contact

intelligence, transport, and forward supply missions, as well as area surveillance. They could also be equipped with payloads enabling them to deliver effects on the opponent. Their implementation might be more complex but could be ensured by non-specialized units. These assets could be gathered at the combined arms task force or combined arms company team level and employed together or given as reinforcements down to platoon level.

3. *Puppet-type systems,* which will make it possible to temporarily robotize the vehicles of a combined arms task force, depending on the missions and the operational requirement. The mission equipment would be removed after the mission and the vehicle put in a normal configuration again. This contingency robotization would make it possible to fulfil all the missions of a combined arms task force. Nonetheless, it would be preferably implemented for contact intelligence missions, convoy escort (a robotized vehicle to scout the convoy's route), forward supply, or battlespace exploitation. Robotized vehicles would have a limited functional autonomy. Their remote operation would be preferably achieved by their usual users (driver, vehicle commander, gunner) from portable or dismountable control stations. The switch to the remote operation configuration could be eased by the introduction of modern vetronics in the new vehicles, making it possible to remotely implement all their sensors and shooters.
4. *Heavy tactical robots* which will have a high functional autonomy, designed and developed in order to fulfil specific missions. More complex, their implementation from portable or dismountable stations would *a priori* require the competence of specialists for whom it would be the main job. It would essentially be robots dedicated to the shaping the battlefield or to aid mobility, with capacities to open routes, clear areas, conduct earthworks, etc.

Interoperability—Environment

These new assets, implemented down to group [squad] level, will have to be integrated within the combined arms task force capabilities. Their environment will comprise of:

1. Transport and combat platforms (multirole armored vehicle (VBMR), armored infantry fighting vehicle (VBCI), wheeled-gun armoured vehicle (ERBC), etc.)
2. Aircraft (close support and combat TIGER helicopters, CAIMAN, etc.)
3. Direct support engineer platforms (MAC),
4. Intelligence systems,
5. FELIN combatant systems,

6. Weapon systems and infantry weapons (rocket launchers, assault rifles, machine guns,)
7. The SCORPION combat and information system (SICS).

The air and ground assets of contact robotization will thus have to be interoperable with all these capabilities. Moreover, they will have to be taken into account in the existing training systems, then integrated in the future simulation environment of the SCORPION combined arms task force. Lastly, the employment of flying robotized systems will have to be integrated in the I3D[6] and to take into account the co-ordination with other effect-producers and sensors playing a role in the 3D environment of the battlefield.

The appropriation of robots by the personnel of the combat, combat support, or combat service units is a significant challenge for robotics. In order to be so, the robot must be easy to use, solid, and inspire total confidence in the personnel who are going to maneuver and act with it. The success of this appropriation first lies in the man-machine interface which is of paramount importance. It must be not only naturally intuitive and accessible to the combatant, but also comprehensive enough for the operator to perceive the environment of the robot and its reactions; failing that, he will not be able to control it in a realistic way in the stress of combat. Lastly, this necessary appropriation will be based on adapted and regular training for the employment of the robot in an operational framework.

Conclusion

The robotization of the combined arms task force has been initially conceived to be part of step 2 of the SCORPION program by 2020. The research conducted has clearly shown that the dismounted component could be quickly implemented given the technological maturity of this equipment, which is available off-the-shelf and which, for most of the equipment, have been combat proven. In the same way, it appears that the mounted component still needs to be developed, especially in the field of the functional autonomy of robotized platforms. It seems reasonable to envisage acquisitions by 2020 for these systems.

In an incremental approach, the French Army has thus initiated the robotization process of the combined arms task forces through procurements for the operations outside national territory. The capacity to neutralize mines and explosive devices through robotized assets should thus be rapidly augmented.

Moreover, in 2012, a tactical assessment of various systems (micro-robots, mini-robots, and micro-UAVs) aimed at increasing the contact intelligence capabilities was carried out within infantry and armored units. The objective was to assess the operational added-value of these systems as well as the combination of their effects, in order to define an appropriate distribution within the combined arms task force and to evaluate the impact of robotization in terms of doctrine, organization, collective and individual training.

This tactical assessment must make it possible to then launch the robotization process of the Army, avoiding some pitfalls and permanently seeking:

1. To limit to a maximum the increase of the physical and cognitive burden of the combatants.
2. To integrate these new assets, both in vehicles and in information and combat systems.
3. To integrate these new assets into maneuver, which must not be limited by their use.

Notes

1. SCORPION is a decisive armament program for the French Army. Conceived following an incremental logic process, articulated in two steps, it is aimed at completely transforming the capabilities of the combined arms task forces between 2011 and 2026.

2. The staff objective is a first official expression of the operational requirement.

3. This working group included members of the Army Staff, the Procurement Agency, the Army Technical Branch, the School of Infantry and the Land Force Command.

4. This triple objective is translated in the Anglo-Saxon acronym "3D" or *"Dull, Dirty, and Dangerous."*

5. Double meaning of the term: mounted within vehicles of the combined arms task force or tactical robots with a certain level of functional autonomy enabling them to integrate into a mounted maneuver of the combined arms task force.

6. Stake holders in the 3rd dimension

Chapter 21
Battlefield Robotization: Toward a New Combat Ecosystem
by Michel Yakovleff

Part I: The Major Choices Regarding Conception

Every technological evolution has an impact on the battlefield; this historical fact is as constant as war itself. Iron replaced bronze then steel replaced iron. The development of chemistry has given birth to Greek fire, then to explosives and, combined with the development of metallurgy, resulted in the invention of firearms. Mechanization has ruled the horse out of the battlefield and opened the aerial domain.

Miniaturization, computerization and other technological advances currently enable the emergence of robots, the number and capabilities of which seem to be likely to increase dramatically. We have long moved past the point of whether the introduction of robots into the battle is desirable or not. The point is to imagine the timeframes and circumstances of this new capability. We might otherwise repeat the futile quarrel between the cavalrymen and the supporters of motorization after the First World War. Nonetheless, acknowledging what is unavoidable does not necessarily make it pleasant. The danger is of course to exclude man from the battlefield. We could imagine that, in the long run, totally autonomous robots would fight each other, on behalf of human beings but not in their presence. This may be the ideal future of war, but certainly not that of humanity. Any reflection on robotization must include, as a watermark, this major conceptual and moral reserve.

How Can We Define a Robot?

The robot as we mean it in the framework of this reflection has three major characteristics:[1]

1. It moves by itself, at least for the major part of its missions. A robot is an autonomous mobile device, both from a mechanical point of view (it does not have to be pushed, pulled, coupled, carried, launched, thrown, at least for the majority of the tasks it is likely to be entrusted with) and, more importantly, from a decision-making point of view.
2. It acts, since it has a function in addition to that of moving (it observes, carries, fires etc.). This point is important because, in the current framework of robotics development, many robots do nothing but move. We are going to emphasize operational functions far more than movement.
3. Most importantly, the robot has decision-making autonomy, meaning that it adapts its behavior to its environment, in a more or less predefined way, determined by the algorithms the designer has integrated.

Disclaimer: The views and opinions expressed in this article are those of the author and do not necessarily reflect the views or opinions of the French MoD or NATO.

Some devices move but remain operated, likes UAVs or the robots used by the bomb disposal experts. In that case, and in line with our reflection, using the word "robot" is excessive. A remotely-operated device, whatever its degree of sophistication, is not a robot. On the other side, some devices are fully autonomous but cannot move. The mine is the most basic example. It has generated the family of remote sensors, the only difference from the mine being that they send information instead of exploding. In that case, functional autonomy deprived of any movement capability excludes them from the family of robots.

How Can We Define the Functional Autonomy of the Robot?

By definition, the robot has an autonomous perception of its environment as well as a reasoning and decision-making capability which interacts with it. The decisions it makes stem from predetermined algorithms but limit human intervention to the maximum; it would otherwise be a remotely-operated device again.

In principle, robots will be all the more useful as they will be more autonomous, precisely because their autonomy makes the work of men lighter. In the same way, the more a dog can do, the more useful it is.

With the so called "artificial intelligence" technologies, we know how to design objects in simulation systems, able to fulfil a tactical mission autonomously. They apply doctrine, they implement the know-how necessary for the mission, they perceive their environment and their peers, and are able to accumulate experience from their operations owing to retroactive loops. For instance, in a simulation system, we are able to make up a combined arms unit with main battle tanks (MBTs) and crews to reconnoiter an axis, deploy in front of an obstacle, look for a bypass route – while ensuring they cover the unit during its search—equip a breach, and cross and come back to the assigned axis in order to continue the mission. In case of an encounter with the enemy, they open fire, call for combat support, conceal themselves, maneuver, etc.

We have been able to do that for approximately ten years on a computer in such a credible way that these programs make it possible to focus minimal control on these operations in a CAX-CPX exercise, for example, therefore saving many tactical subunits necessary to feed the echelon playing the events. There is no conceptual obstacle to be overcome to apply these algorithms to real objects operating in the physical world. The robot we will soon see on the battlefield—if it is not present already—is thus able to receive a mission and to fulfil it with no more interaction with its human master than the personnel it is supposed to replace; this would be the major efficiency criteria which would justify choosing a robot instead of a man. It must at least be able to do as well for the best part of its mission.

The limit to autonomy is very clear if the robot in question has an attack capability: it should not be able to fire without a positive order. Here, the comparison with the military working dog is enlightening: when a well-trained dog perceives a threat, it sends a signal to its master (it growls, lowers its ears, etc.) but it needs an explicit order to attack. On the other hand, the robot must be able to protect itself without asking its master, by achieving an evasive maneuver. For instance, depending on the plasticity of the robots, we could envisage a leap backwards, an evasive action, or even a defensive distortion comparable with the lying of a man under fire: the robot would for instance spread all its sensors and “limbs” in order to limit its vertical profile or, on the contrary, it would pile them up in order to hide behind a post. In that respect, a modular articulated conception inspired by the Rubik’s cube seems to be an orientation to be privileged.

The Context of Engagement

In order to justify the investment it requires, battlefield robotization must bring real added-value by doing a task better than man, by doing the task differently, or by doing a task which still has to be invented but which will unavoidably appear, in accordance with the logic followed by information technologies which have seen the emergence of requirements and functions not envisaged in the beginning.

For reasons which will be detailed later, we consider that combat robots will bring the best added-value in operations in urban areas, at short range, in conjunction with dismounted troops. This does not exclude the usefulness of robots in other functions, with a much higher range of action than that of dismounted infantry. Nonetheless, for Western countries, which will always have an issue with troop numbers and are anxious to protect their soldiers, priority will inevitably be given to situations of critical force ratio and dangerous environments.

Three differentiated roles can thus be given to robots: sensor, attack (aggressor), and servant (logistics). As we show below, we consider that these tactical robots will be essentially focused on a sensor role, with a significant portion dedicated to the “servant” role. The number of aggressor-robots would be marginal. This idea may be counterintuitive, in view of the current efforts to develop aggressor-robots. We think that this priority is wrong.

The central problem is indeed that of detection and discrimination. No robot will be able to detect and identify any type of hostile intent. It will however be able to detect presence or movement, whether recent or on-going. In order to discriminate, cross-checking between various sensors will be of paramount importance. Therefore, when we think about battlefield robotization, we think about groups or even multitudes of robots.

The primary objective of these groups of robots will be to extend and deepen the information gathering area forward, but also on the flanks and in the rear, both on high terrain and underground. The first conceptual conclusion is therefore that the battlefield robotization concept itself requires many robots, and we think that they would generally be single-sensor and of limited size.

We cannot envisage using human resources to control this many robots, even if this has recently been tested (in France). These robots thus have to be individually autonomous as soon as they have been given a mission, but, more importantly, they have to be *collectively* autonomous. In the field of artificial intelligence, this behavior is called the swarm. Each component has an extended autonomy of action, especially to guarantee its own survival, but each one permanently envisages its action in the extended context of the entire set. Many individual wills are thus integrated into a collective will.

Thus the second conceptual conclusion is that robots will act in swarm. As a consequence, the development of battlefield robots cannot be envisaged without the development of both the individual and collective algorithms governing the mission. It is important to start with that, before developing devices, rather than following the opposite logic, which is to develop robots then to put them into a synergistic system.

The Impact of Combat Robots on Future Combat

In order to do better, we can easily envisage that a unit conducting reconnaissance or surveillance over an area will act more quickly and ensure better safety for its personnel if it is surrounded by a swarm of sensors. Though it can never be eliminated, the risk of tactical surprise will be strongly reduced. Besides, a surveillance swarm enables the unit—the human part of it—to focus its attention on the most dangerous area, while for instance avoiding dedicating strength to the rear guard or the flank guard. The ratio of soldiers useful for the main combat action will be enhanced. Knowing that a moving platoon maintains 30% of its strength in second echelon to cover itself rearward and to provide a maneuver reserve, suppressing or reducing this requirement generates a more favorable offensive ratio. Logistics is manpower-consuming, increasingly so as we get nearer to the zone of contact. In the rear, the large logistic bases would require use of few personnel owing to mechanization (especially with sorter-packers and loader automation). The massive robotization of this function can be envisaged. It will free a small number of personnel but the gain will remain significant. But closer to the frontline, the transfer of fuel from tank-trucks to jerry cans and carrying them forward is awfully manpower-consuming. What is true for POL is also true for ammunition, supplies, etc.[2] Bringing a wounded man to the proper level of medical aid requires approximately ten personnel for one or two hours. Though the medical treatment itself should remain a human task, all the transport mechanics could be entrusted to robots. This is where robotization would allow the process to be more efficient.

To do things another way, many possibilities brought by this new combatant ecosystem remain to be explored. Since we have established that artificial intelligence will be its determining aspect, this exploration can start today, in simulation, even before having designed the devices. Operational research needs to anticipate the development of devices. It is not so expensive and will undoubtedly prove to be crucial to explore the most exotic routes, clear up doubts, and confirm options. The most probable result is that the decrease of the uncertainty and unknown tactical factors weighing on any unit feeling its way searching for the enemy will deeply modify its aggressiveness and more particularly its tactical movement speed outside the disputed area. The speed of movement under the threat of a probable enemy presence is currently limited by the necessity to keep a support element ready to react as soon as the enemy unveils himself. If the considered unit knows, with a higher degree of certainty, that it is not under immediate threat, and if it discovers the enemy earlier and with more precision than before, it will have a higher speed of maneuver. Its task organization will undoubtedly be modified, owing to the better ratio between the parts reserved to the offensive and those preserved to react to an unexpected event. In the long run, these changes should also have consequences on the allocation of weapons. In the same way, during an operational pause, the entire unit will be able to rest and recuperate, without needing to maintain sentries, if it trusts its robotic escort enough. Keeping in mind that the security function generally requires 10% of unit strength, this is another situation in which a significant part of combat potential is preserved and can thus be reinvested.

New ideas, that we do not envisage today, will undoubtedly emerge sooner or later. When the first computers were developed, they met the need to handle a mass of data. Nobody could imagine the office automation applications or even the games existing today. This logic will inevitably apply. The most imaginative will seize a significant advantage over the hesitant or uninspired. There again, operational research will prove to be fertile.

War between robots will certainly be an explored path. The history of aviation is enlightening in that respect. At the beginning, aviation was used to observe and the pilots used to greet each other while fulfilling their mission. Then, one of them decided to get rid of an intruder, drew his gun and fired at him, triggering an escalation and specialization which is still continuing one century later. Today, the fighter component is the most symbolic part of modern aviation. We can thus presume that two "robotized" units will consider that one of the tasks required is elimination of the adversary's robots. The human combatant will therefore, sooner or later, be tempted to leave the battlefield to robots only. We would then reach the ethical limits of the exercise, which will have to be envisaged with scepticism.

Partial Conclusion

As a conclusion, battlefield robotization should see the emergence of a robot-based ecosystem operating in swarms. The development of artificial intelligence will be of paramount importance to exploit all the potential of these devices. Operational research can already determine the desirable characteristics both of the individual devices and of their collective action for and near humans. This operational research has to be conducted before the development of devices as such. In Part II below, we will examine the most probable physical characteristics of these devices as well as the way to control them. In Part III, we will envisage the tactical, psychological and ethical consequences of their introduction in the combat environment.

Part II: The Major Characteristics of Robots

The major characteristics of robots we propose to think about are the function, size, appearance, range of action, and speed, all of which allow us to foresee that stealth will undoubtedly be a crucial issue for the designers.

The "Aggressor," "Sensor," and "Servant" Functions

Let us start by asserting that, given the current technology and its predictable evolution, the issue for the designers is not the attack capability. We already know how to kill and neutralize, from any reasonable distance, with an accuracy which should reach its functional limits soon. Indeed, as soon as we are able to limit and nearly cancel collateral damage, provided we use the appropriate ordnance at the appropriate moment, it is no longer useful to enhance the intrinsic accuracy of a weapon system. We already have the necessary accuracy. It is currently the case, or nearly the case.

Having made that provision, we can imagine that future robots will fulfil, at least in an initial phase of battlefield robotization, one of the three following functions: attack (aggressor robot), sensor, or servant (logistics).

First of all, the pre-eminence of the "attack" robot, the machine that is armed, seems to be debatable. Without completely excluding it, two reasons limit its interest. The first one—the most determining by far—is the one mentioned in part I, namely, the necessity to include man in the decision-making loop. Since the robot has to ask its master before firing, you might as well place the master in a situation where he can decide and fire as it will always be quicker. It will also be safer from a discrimination and proportionality viewpoint.

The second reason pertains to mechanics. Even if you admit that discrimination remains the responsibility of man and that the robot just has to send out sufficiently discriminating pictures of possible objectives, the complexity of a firing platform, its aiming performance, its ability to absorb recoil, to reload, etc. imply a significant technological breakthrough if we want to replace the current systems: either man himself, for small calibre, or the operated or remotely-operated device for more powerful armaments. Currently and in the medium term, the law of decreasing returns is in force and the best firing platform remains man or the operated/remotely-operated device. We could devise attack robots with non-lethal functions or payload, such as the ram robot (to break through a door or a wall) or the smoke dispenser robot. This does not change fundamentally the envisaged taxonomy.

However, some environments do not enable man to fight on a sustained basis, such as contaminated or undersea areas. In these two specific contexts where discrimination is easier since the non-combatant cannot be part of the environment, we could conceptually admit the interest of "true attack" robots. They could contest the area against the opponent without endangering the life or health of human beings. A possible employment would be for instance the submarine defense of oil rigs with "shark-robots" aimed at eliminating the threat of scuba divers. That being said, the real added-value of such a robot, compared with a miniature torpedo tube anchored into one leg of the platform and operated from the bridge or from a distance, seems questionable. This illustration leads us to conclude that complex or new situations do not always justify the invention of robots and that it is preferable to explore proven solutions first. One does not robotize for fun but to make up for an absence of a solution.

The "sensor" robot seems to be the prevailing path, at least in the medium term. Once again, in the framework of this reflection, it is worth noting that UAVs or remote sensors are not robots, even if they are very efficient sensors.

By extending intelligence collection areas for a unit, by making it possible in areas where soldiers cannot go, or only with difficulty or heavy risks, the robot would bring an undisputable added-value which can already be perceived with current technologies. We are currently able to develop optical, sound, seismic, radio, and radar sensors, with a much higher definition than human capabilities. For instance, optic observation can cover ranges which are invisible to human eye. In the short term, by developing mass spectrograph technology, we should develop "sniffer" robots, able to identify chemical components in the air, on or under the ground, being thus able to spot a buried explosive device or chemical contamination. Similarly, seismic or tactile technology can detect modifications of the ground texture, indicating works such as buried mines or the presence of an electric wire. The basic technologies already exist and their miniaturization, at reasonable costs, should give results in the near future.

Regarding the "servant" robot, there are already some of them under the form of load-carrier "mules," able to follow man along a mountain path. The current mine-clearing robot is not a robot as we define it in this article yet, but a sophisticated remotely-operated device. It may be interesting to make it autonomous, able to reconnoiter a route or an area and to defuse or neutralize any encountered device, possibly without any human intervention (though it would be possible to include an execution order between the discovery and the neutralization of a device).

Many forward logistic operations lend themselves to robotization, for the same reason that robotics has invaded civilian logistics, in particular in huge distribution centers. Be it to sort and allocate ammunition, spare parts, supply, to pack and store, to count and check, there are already robots proving to be quicker, more enduring and more reliable than man. Bringing "customized" logistics as close as possible to the soldier is also a likely possibility and which already exists as a prototype.

A variation of the "servant" robot could be the radio relay-robot, inserted in the depth of the enemy zone. For all that, a discussion on the actual need to robotize this function shows the limits of the exercise. Indeed, a re-transmitter can be projected to a distance as a rocket submunition, or dropped from an aircraft. In such a case, the robot would not consume any energy from its own reserve for insertion, which would not be the case of a vehicle-robot autonomously conducting a long range infiltration.[3] Besides the fact that it could be seen while moving, tracked and even "turned" (in the meaning spies give to the word), the most critical factor would be the energetic ratio which would just be unacceptable. Though this discussion might seem superficial, it shows that many solutions, already existing or easy to develop, are intrinsically more cost-effective than robotization.

We can draw a first typological conclusion from what is mentioned above. In a booming tactical family, the sensor robot should represent the large majority of the products deployed. The attack robot will undoubtedly exist in a near future, but should remain marginal in numbers for a long time because it will be limited to particular cases. There should be more numerous "servant" robots, since the state of the art seems to be close to meeting operational requirement. If we make an attempt at prediction: within the ten coming years (2020-2025), the robots on the land battlefield will most likely be 70-80% sensors, servants 20-10%, attack 5-10%.

What Size Will These Robots Be?

The size of each robot will of course depend on its function.

The size of an "attack" robot will mostly depend on its armament. Except if there is a technological breakthrough, such robots should not be significantly smaller than the current remotely-operated platforms, since they would have to embark a base stabilized on the three axes, able to absorb the recoil, carrying its fire control apparatus and ordnance, all that being placed on the fully mobile platform which means that we are talking about a robot and not a sledge. In the light of what is currently done, for instance, to carry a medium-caliber machine gun or an antitank missile launcher, the ratio seems to be one half. We mean that a remotely-operated device able to carry and haul a machine-gun measures up to one meter and weighs approximately 50 kilos; a larger device carrying antitank armament takes half the volume of the corresponding armoured vehicle, simply because it does not need the internal space necessary for the crew. Between the remotely-operated device and the robot, the difference in volume seems minimal, or even negligible, the sole difference being the presence or absence of internal algorithms, making the device autonomous. To be specific, the volume of the box ensuring the liaison with the pilot of a remotely operated device is not so different from that of a device enabled with artificial intelligence. All the rest—mobility, protection, power, armament, signals—does not stem from robotization as such but from the miniaturization of each component.

A comparison with UAVs is enlightening: the huge UAVs, which operate at high altitude and for long durations, have a size comparable with that of airliners. Remote operation has not led to a significant decrease of volume and weight but to the useful duration in zone (so-called "loitering time"), since the pilot is no longer inside thus dispensing with the physical limit of human endurance and increasing the fuel payload.

The size of "sensor" robots obviously depends on the sensor and, in this field, we can see that miniaturization is rapidly progressing. Some cameras weigh only a few grams and can fly on devices the size of a big insect. The other envisaged sensors (radar, radio, sound, seismic, chemical) should follow the same path, without necessarily going as far in miniaturization as the optic range.

Addressing that from a non-scientific neophyte's viewpoint, it seems that a first generation of sensor robots will become operational for payloads ranging from a few hundred grams to a few kilos. This would make the development of portable robots possible, from pocket size to backpack size. There is hardly any reason for conceiving right now a hundred-kilo device to carry a high-power lens, with a definition and range useful for man.

The robot will therefore be single-sensor, allowing for exceptions, mainly for reasons of simplicity and reliability. We may be tempted, initially, to place several sensors side by side on the same mobile platform (for instance one or several optical sensors combined with a mass spectrograph). At first glance, this seems to be a mistake because the essential complexity of the robot will not be the sensor but the platform which makes it mobile and "survivable." The potential interferences between very different sensors will disproportionately complicate the overall integration. Synergy will have to be sought elsewhere, through the swarm effect; we will come back to that. Except in some cases, the trend will finally go toward single-sensor, usually light robots of modest size, generally transportable by one man.

The first really functional generation of sensor robots should include devices in sizes ranging from the mouse to the big dog, the average being the cat. This idea has significant tactical consequences which will be discussed later.

Regarding "servant" robots, they could be more bulky since they would essentially be used to carry loads or manipulate things (bomb disposal devices, for instance). In rear depots for instance, these robots could be very big, ranging from one to ten tons, to manipulate heavy loads. In combat areas, endurance, stealth and the range of required loads would imply a more limited volume. The size should start with that of a big dog and go up to that of a mule. Beyond that, the size would be comparable with that of a manned vehicle and it is difficult to envisage the conditions which would make the robot more efficient than current operated vehicles, future remotely operated land vehicles, or even a column of vehicles connected to an operated one (in automated convoy).

Hence this second typological conclusion: the more numerous robots, by far, should be the smallest ones, but not necessarily the miniature ones, the "big ones" being generally limited to attack or support roles. This conclusion has consequences, because if the most widespread robot tends to be the cheapest one, nearly by principle, the development and deployment of this capability will be easier.

What Will They Look Like?

Regarding the shapes of robots, and especially those of the smallest ones, they will mainly be inspired from nature because it is expedient to start with that. A 7 July 2011 article in *The Economist* titled *"Robots: Zoobotics"* offers very convincing arguments in favor of a logic based on the way species evolve. Indeed, shapes and forms encountered in nature result from millions of years of selection, an experience it would be vain to ignore. Some flying devices, able to make prolonged stationary flight, are already inspired by insects. A submarine device used for some tasks could be based on the octopus, the plasticity of which enables it to get everywhere while benefitting from a remarkable mechanical strength compared with its mass. A prototype is already being developed, in order to make a robot able, for instance, to operate submarine devices. A device supposed to penetrate everywhere, but without being obliged to do it quickly, could look like a snake or a centipede. For small size ground robots, the shapes of spiders are a good compromise between the ability to get everywhere and, if need be, to leap ahead, the legs acting as planes for the aerial phase; the initial impulse could be obtained through a bound or the emission of a gas or compressed air jet.

Third typological conclusion: the conceptual borrowing from the animal world should be the starting point. Apart from robots moving on wheels or tracks—undoubtedly the biggest ones—the large majority of shapes will stem from nature. They will thus give rise to human reactions marked by culture or a personal experience; that is something on which we will come back later because it has implications on the acceptability of this new family of soldiers.

Range of Action and Speed

Theoretically, we should be able to conceive ground sensor robots with a long range and a high endurance, able to cover hundreds of kilometers, following the same logic as that which prevailed for the development of UAVs. We can imagine a robot dedicated to route reconnaissance, leaving Frankfurt in the morning and arriving at Berlin in the evening, without any human intervention. This has been done in the United States, within the framework of three competitions organized by the US Defense Advanced Research Projects Agency (DARPA) and the progress made between competitions was amazing.

Even then, apart from a reconnaissance limited to the most technical aspects (e.g. conditions of the road), excluding any risk of making a hostile encounter, nothing will replace the immediate and continuous action of man. We currently can conduct combat reconnaissance with men. Replacing the lead man with a robot could be so all-consuming for Soldiers—to follow, understand and decide—that in the end, replacing the lead man becomes meaningless or does not bring any real tactical gain.

However, radiological reconnaissance, in a contaminated area, but without any interactive opposition (without any enemy) can be envisaged right now. For instance, in Japan, after the tsunami and with the risk of nuclear contamination, robots could have been used to determine as quickly as possible the map of possible routes or the level of radiological contamination over an area. For all that, we are able to do that from a distance with UAVs, the air or spatial imagery and radiological sampling conducted from helicopters. We are able to do it now (and we indeed do it), with proven technologies, at acceptable cost since they involve already existing devices which can also fulfil other missions—such as helicopters—which would not be the case with most robots. In a nutshell, the economic and functional calculation of this change is not conclusive. It is another illustration of that which is possible, even at reasonable cost, is not necessarily the best solution.

This leads us to our fourth typological conclusion: the long-range land robot seems to be conceptual nonsense, or at least without any obvious operational added-value. Apart from very specific cases, it seems reasonable not to dedicate too many resources to this type of research.

Regarding the moving speed of robots, we must consider two aspects: maximum speed and tactical speed. The maximum speed is necessary for the last leap or to escape a threat. In this case, the word "leap" is appropriate because in most cases, the way of moving of the robot would be similar to a leap (aerial phase resulting from an impulse, to be distinguished from a flight during which the aerial phase is maintained). The energetic ratio of a device designed to reach a high instantaneous speed, but without having to make it endure, is very different from that of a device able to move at this same high speed over a long period of time.

The tactical speed is the speed to be maintained throughout the mission, and there, paradoxically, the need is reduced. An infantry unit can cover six kilometers in an hour, but in reality it maneuvers at three kilometers per hour and fights at one kilometer per hour (because the movement of dissociated elements, which stop to support, search, and observe, makes the whole of them move at this low speed). A robot supposed to accompany walking men therefore does not need to be able to reach 60 km/h. It is useful for the robot to reach this speed for a leap, but it is unnecessary for it to maintain that speed for more than a few minutes; it would otherwise separate it from its human escort. If the unit moves at 60 km/h, its robots will travel by vehicle and will get off to conduct dismounted combat. In concrete terms, for a robot meant to accompany men, a maximum speed comparable with that of a dog would be largely sufficient.

The tactical endurance of these devices does not need to exceed too much that of the human unit they accompany; we are therefore talking about a few hours of autonomy, one day at most, because the resting time of the unit should allow a reload of the batteries or a refuel of the devices.

The fifth typological conclusion stems from what has just been stated. In the field of conception, aiming at reaching high enduring speed is most likely useless. However, being able to move during several hours at 8 to 10 km/h speed (to maintain a margin relative to a walking man) while being able to make repeated leaps is an exploitable basis for program specifications and remains within reach of reasonably achievable technology.

The Issue of Stealth

Robots of limited size, moving on the ground, and sometimes making leaps, can be silent if current technologies improve a little. They could thus be quite stealthy, at least in a normally noisy urban environment. But in a quiet town or in a peripheral area at night, significant improvements have to be made to make a swarm undetectable from a short distance. It is nevertheless an important condition for any system focused on intelligence acquisition.

It will certainly be much more complicated for flying devices. The laws of physics brutally apply. For instance, the apparatus required to muffle sound is bulky, reduces the energy output and makes the device heavier, requiring additional power which induces more noise. After all, after one century of mass aeronautics, there is no noiseless commercial or military aircraft yet. There is constant and real progress but we will not have silent aircraft soon. It is a gamble on the future to assert that a long-lasting and resolute effort should be able to produce noiseless or nearly noiseless flying robots. It is not impossible that at a certain level of silence, the law of decreasing efficiency applies and that the flying robot, capable of operating in very adverse flying conditions and stealthy enough not to draw attention just cannot be achieved. However, a technological breakthrough is not impossible. Yet, the work on the acoustic trace of robots of all types will certainly represent a major component of the conceptual effort, as is already the case for submarines.

This is not a minor detail. The objective is to integrate the acoustic criterion as a major initial component of the device design, and not as a consequence of technological choices focused on the scope of action, speed, protection or other essential elements. In the field of acoustics, it is very difficult to make up for a major fault, inherent to the conception itself of the device. It is not inconceivable that the acoustic signature of the robots will be the most significant technological obstacle to overcome, thus delaying the emergence of this family of devices.

To fine tune their characteristics, we have to imagine them in a tactical situation, which will be the subject of the third part of this article.

Part III: Tactical, Psychological, and Ethical Consequences

It is generally agreed that future ground combat will mostly be in the city (urban areas), amongst populations, against an asymmetric enemy merging with the population at least until combat, and often during and after it.

What Could Robots Be Used For in This Context?

In the previous part, we have asserted that the most widespread robot would be the sensor robot, generally single-sensor, acting in a swarm to complement the dismounted unit. The latter would be preceded by several robots, the angles of observation of which would overlap while multiplying the types of observation (visual, seismic, electromagnetic and even olfactory). On the flanks, other devices would ensure security from a predefined distance depending on the threat and the human environment, which would not necessarily be hostile. It would be the same for the rear. In urban terrain, it would be useful for the deployed "bubble" to observe the high ground, hence the interest in having a climbing and movement capacity on a vertical wall as well as a capability to jump from one wall to another. Lastly, the surveillance could be made subterranean, with robots moving through underground passages thanks to their limited size and their ability to operate in the water.

What Relationship Between the Robot and its Master?

As already outlined, it is unrealistic to pretend to desire control of each robot element individually. Thus artificial intelligence is an imperative. In order to limit the burden on human attention, the dialogue between the individual components should also be autonomous. For instance, a robot could change side of a street while moving to better cover the dead angle of one of its fellow machines without any human intervention. The sensors would be constantly distributed by the artificial intelligence.

Similarly, and though it may seem counter-intuitive, robots should not transmit information in real time to men. The flow of information would be transmitted only in case of an alert and through a filter that has yet to be defined. In other words, the moving unit's human component would in most cases not observe through the eyes of the scouting robots but with its own eyes. It could of course use the transmitted picture on call.

The behavior of each individual robot and that of the swarm would be defined by a combination of reflex actions and orders. A single operator would therefore give the overall mission to the swarm, the direction, the objective, and other instructions, as we already do with humans. The swarm, and each of the individuals which compose it, would act on its own initiative depending on what it can do (artificial intelligence) and on the signals received from the environment (including the behavior of the unit it moves with). From time to time, it would receive a precise order, usually a refocusing or new instructions, which would induce a new behavior. In that context, a single operator would be able to control the entire swarm.

Yet, if a threat appears, some of the robots should be controlled individually since a single operator would not be sufficient to adapt the maneuver.

There is a major limitation to the deployment of a swarm: the necessary bandwidth for the information flow in both directions. This bandwidth must be protected because it will be attacked, almost by principle. This limitation cannot be removed today but it undoubtedly will be one day or another. By the way, the concept proposed below is aimed at limiting the need for bandwidth, at least apart from the active phases of combat.

Hence a Concept of a Three-Phase Man-Robot Dialogue

1. Routine, no danger assessed. In this mode, the ideal set up is a single operator. Except for a few glances, the unit lets the swarm operate as it wishes. The swarm adapts its tempo to that of the unit, abiding by parameters defined for the mission, including the security distance on each side (forward, flanks, rearward, upper locations and subterranean).

2. Alert posture induced by the detection of an indicator or warning. The swarm, like a dog, suddenly stops and adopts a security posture. The unit takes defensive measures and appeals to the sensors which have signalled something. Consequently, if each soldier has "his" appointed robot, he captures the picture or the radar screen on his own screen and interprets what he can see. The commander, in contact with the collective artificial intelligence, interprets the cross-checked data.
3. Maneuver, depending on the interpretation of the piece of information. If need be, the tactical commander can modify the maneuver of the sensors in order to optimize operations over a given area. It is worth noting that the embedded artificial intelligence increases its operational experience and improves its quality, to such an extent that when a similar situation occurs later, it adapts its behavior without further human intervention. We can already do that with a computer, in a synthetic world, nothing prevents us from extending this capability to the physical field. In that situation, some sensors are operated in real time, and the information they feed is exploited in real time.

As already noted, we do not really envisage the combat robot, participating in firing in case of engagement. In the preferred case, the well-informed human unit assesses the threat and, if the need arises, conducts the firing. Meanwhile, the swarm participates in giving information on its result (live and non-stop *battle damage assessment or BDA*), while maintaining surveillance over adjacent areas.

This conclusion may seem counter-intuitive but it is essential: the dialogue between the robot and its master should be as limited as possible. It is not a paradox: the human component must retain as much freedom of action as possible and not be consumed by running the robotic component (and, incidentally, use less bandwidth). In concrete terms, the approach to be preferred is a three-level dialogue, adapted to circumstances.

Some Ideas on the Tactical Structure

Until now, we have envisaged close combat, in urban terrain, dismounted (at least for humans). In that respect, the basic tactical element would be the platoon (approximately 30 personnel), accompanied by its robotic ecosystem which would essentially provide information, with a possible logistic component. Let us leave aside for the moment the fact that what 30 personnel do today will certainly be done with less in such a context. The same tactical effect could be obtained, in the case of a "robotized" platoon, by 10 or 15 fewer personnel. If we seek to save on manpower at all costs, the downsizing will still be limited by the number of robots to be implemented, which should result in the ratio of one man-one robot, even in the case of a super-efficient artificial intelligence. In the end, in contact, one soldier will be needed with each robot to observe with its eyes and if need be to maneuver it. After all, a dog-handler only handles one dog.

In case our conclusion about the preeminence of the sensor robot is confirmed, it seems more relevant to reverse the proposal and to preserve troop strength since the combat capability will remain the prerogative of man. At a given level of manpower, robotization at the tactical level will considerably increase the efficiency of a unit; it is another way to compensate for numerical inferiority which is a key element of the engagement of Western armed forces in modern conflict, be it asymmetric or not.

The platoon would be equipped with its own set of robots, at least as long as the endurance of men and robots is the same. The operational resting periods will be profitable to both. If the swarm of robots has a much higher endurance, the same lot could be handed on to successive platoons. But it will be more expedient to limit the endurance of robots to a given mission, with some reserve for comfort.

The company having three or four of these platoons should have some broader capability. For instance, if a platoon acts in a half-square kilometer area, its parent unit should observe in the next half-square kilometre zone and even widen that area a little. That being said, this observation capability already exists, with devices operated from a distance (the UAVs). Some of them could be robotized (meaning that they could be made autonomous), but the tactical added-value is not convincing. We should be able to make do with an observation capability from the air and space, with a dozen-kilometer range, during a long period of time—a capability which currently exists.

In the end, battlefield robotization brings the highest added-value in "retail combat," in close contact, much more than in the context of extended or long range engagements. Robotizing a long-range, long-lasting combat capability does not appear to be a profitable objective at the moment.

To conclude on the tactical employment of robots, it should mainly concern the lower echelon, certainly the current platoon level, which would be "robotized" with a swarm allocated to it; three or four platoons would constitute a company with its own observation and detection capability into forward zones (using remotely operated devices rather than robots); at the higher echelons, combined arms maneuver would not be significantly impacted; yet, the logistic function, above all in the forward area, would make massive use of "servant" robots.

We still have to envisage this unit in combat, in urban terrain, in the presence of the population. That leads us into the psychological and ethical aspects of this new capability.

The Psychological Aspects of Robot-Assisted Combat

These aspects are linked to the issue regarding the acceptability of robots. We have mentioned the picture of the unit moving in town, surrounded with its swarm of robots. The shapes and forms we discussed are not necessarily perceived as friendly, like the spider-robot. Even a robot looking like a cat or a dog will not necessarily be warmly welcomed. Let us not even speak about the snake or ground octopus. Let us not forget either that these devices will certainly be noisy, at least at the beginning.

The current soldier, caparisoned and helmeted, wearing dark glasses making him look like a wasp, loaded with devices like outgrowths making his human aspect unrecognizable, is not well accepted by the population, to say the least. It is nonsense to believe that this refusal is "cultural," because the Afghan or Iraqi populations are uncomfortable with the intrusion of Western soldiers. The same Western soldiers, deployed with the same gear and the same attitude in the capital city of their own country would hardly be better perceived or accepted. Visually speaking, the increasing gap between the civilian and the combatant is already a major psychological issue. What will happen when our “extra-terrestrial” human combatant is completely surrounded by a buzzing, leaping, crawling, mewling, whistling swarm?

The odds are that our robotized platoon will have many difficulties in making contact, in a serene and friendly way, with a sceptical or undecided population, not to speak of a hostile one. In that case, robotization could be a disadvantage, or at least a strong constraint requiring heavy tactical adaptations to make up for the psychological effect which goes against the mission.

The Ethical Aspects

Until now, we have structured this discussion from a purely technical perspective. But combat is a human issue and must remain so. We have said above that the long-range robot, able to conduct fully autonomous missions in depth (for instance to control a gap, or harass enemy in the rear) seems to be a conceptual nonsense. So it is from an ethical viewpoint as well.

Indeed, if we envisage a harassing-robot squadron, attacking the rear enemy position, without any or hardly any human intervention, we can conceive that the enemy will design robots to defend his own rear and to track and kill the infiltrated individual, be it a human or a robot. In that case, the result is war between robots, for the sake of humans but out of their presence. This will be a totally new aspect of war, and in reality an absolute horror.

The advantage of the robot accompanying the infantryman, at the infantryman’s tempo, is that it does not dissociate the combatant from his ultimate responsibility. The swarm is certainly a dreadful form of development of combat but it does not distort it to the same extent as the gangs of bloodthirsty robots mentioned above.

Isaac Asimov, one of the most famous science-fiction writers, has studied the ethics of robots and established the three major laws of robotics:

1. A robot cannot harm a human being nor, remaining passive, authorize that a human being be exposed to danger.
2. A robot must obey the orders given to him by a human being, except if these orders come into conflict with the first law.
3. A robot must protect its own existence as long as this protection does not come into conflict with the first or the second law.

Combat robots, such as we envisage them, obviously go against these laws, owing to their very design. Yet, ethical research could start with this foundation.

Let us note first that the robots we have talked about are not mere machines. They are devices equipped with a huge autonomy regarding decision-making; it is even their major advantage. Whoever says “decision” says “responsibility.” Here again, the comparison with the employment of animals is enlightening. A dog-handler remains responsible for his dog. How can the decision-making autonomy of machines be reconciled with the necessary responsibility of their masters?

Whatever the complexity of the algorithms which will determine the behavior of robots, human responsibility will remain fully engaged, at least at three levels: the designer and especially the person who has oriented the artificial intelligence; the tactical commander, who has decided the mission, the tasked unit, and the defined boundaries (including the rules of engagements to which paragraphs dedicated to robots will be added); and the robot's master as such, the one who is connected and who commands it directly. The creation of a "robotized" unit will have to include a significant part of training dedicated to ethics, envisaging the moral limitations of employment of these devices.

Apart from the attack robot, which clearly goes against the ideas of Asimov, even the sensors or "servant" robots will explore the limits of these laws as soon as they have to protect themselves.

As a general rule, we can think that the self-protection of the robot should preserve it from an innocent gesture or from indirect malevolence like that of a curious child or of an exasperated passer-by, which is different from the adversary who knows who or what he is faced with. The first measure of protection and *a priori* the less dangerous to an innocent person is dodging (which does not mean fleeing—in that case, the robot avoids the blow but remains in the area). Dodging may consist in adopting a less vulnerable shape, thanks to the plasticity already mentioned above. Here again, the animal world may offer inspiration in the form of the armadillo or the hedgehog, developing robots which curl up or enter inside a shell, but also leaping robots which stave off the knock by jumping and eventually tire the aggressor. An additional degree of defense could consist of a non-lethal reaction capability like the spines of the hedgehog, the electric discharge of some fishes or the emission of smelly gas (skunk effect). Faced with clearly hostile deeds, most of the robots will remain highly vulnerable because of the ratio between their weight and their payload. The armored robot, able to take a sub-machine gun burst, will be deprived of any agility. The protection of the system rather lies in the bulk effect: the swarm can lose one or two bees and the clear aggression against a robot is a combat act just like any other one, which may lead to the engagement of soldiers.

Let us return to the civilian population. It could attack the robots while avoiding provoking soldiers directly. Let us suppose that an exasperated grocer kicks a spider robot stationed in front of his shop. Will he have to be arrested? According to which legal rule? If demonstrators, masked and carrying bats attack the robots which are watching them, in front of a check point, what will the acceptable options be for the unit? From an ethical viewpoint, can we fire at a crowd to protect a robot?

These are the first considerations that will have to be envisaged before deploying the robotized units we have conceived. It is highly desirable that this reflection take place in close co-ordination with the development of algorithms governing the behavior of robots, since they will have consequences on the behavior of the unit and, finally, on its tactics.

Summary of Conclusions:

1. Combat robotization is on-going.
2. *A priori*, robotization will mainly concern "retail combat," in urban terrain, rather than long-range missions (a few hours, a few kilometers).
3. The sensor robot should prevail, followed by the support robot and in some cases the attack robot.
4. The shapes and forms of the robots will be, for most of them, derived from animals. This conclusion has material and functional consequences but, more importantly, psychological ones, because the atavistic burden will weigh on the acceptability of these new bodies.
5. Most of these robots should be small, with limited range and endurance and a high capability to cross obstacles, generally by leaping.
6. These robots will act in swarms; the development of the algorithm should precede the definition of each individual robot.
7. The intrusion of these robots on the battlefield should be preceded by ethical reflections, which would in turn have consequences on the technological and cybernetic spheres.

Notes

1. French Army General Staff 2011 definition of a robot: A mobile and reusable ground platform, equipped with sensors and effect-producers, aimed at achieving, with a certain level of autonomy, basic actions within the framework of the land maneuver. End-state of land military robotics: enable the soldier to focus on what he/she is only able to achieve, since the robot fulfils some clearly identified tasks in support of or instead of the combatant.

2. Battle and logistics. During the first battle of Grozny (winter 1994-1995), one third of the strength located in the city was consumed by forward logistics and especially the transfer of supply. One heavy consequence was that the soldiers, even taken out of combat, could not have a rest because they were employed for these logistic actions. The wearing out of the troops, physically but above all psychologically, had heavy consequences on the battle.

3. Single rocket launcher. Many nations already operate rocket ammunition able to reach 100 kilometers with an accuracy of nearly one meter. This type of vector could be adapted to deploy a re-transmitter, at a lower cost than that needed to develop a specific robot. Detection might be more difficult than for a ground device, inevitably bound to make encounters. Regarding interception, it would be much more difficult against a rocket, which could drop its load at any time on a path which would continue for few more dozen kilometers.

Combat Studies Institute Press
US Army Combined Arms Center
Fort Leavenworth, Kansas

Visit our Web site at

http://usacac.army.mil/cac2/index.asp

9 780989 137256