Toward Land Operations 2021

Studies in Support of the Army of Tomorrow Force Employment Concept

Edited by
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Foreword

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Preface

As the 21st century unfolds, Canada's Armed Forces must be ready to operate within an international security arena characterized by uncertainty, volatility and risk in order to meet national security needs and expectations. To mitigate the unpredictability of future conflict and prepare itself for the challenges it will face in the years ahead, the Army has recently published *Land Operations 2021: The Force Employment Concept for Canada's Army of Tomorrow*, to serve as the guide for land force development through to the year 2021. *Land Operations 2021* was developed from a series of operating, functional and enabling concepts that collectively describe an approach to future land operations characterized by the deliberate dispersion and aggregation of adaptive forces in order to create and sustain tactical advantage over adept, adaptive adversaries.

This publication, *Toward Land Operations 2021: Studies in Support of the Army of Tomorrow Force Employment Concept*, brings together in a single volume a number of the key studies which generated the ideas and concepts that informed and shaped the development of adaptive dispersed operations, as contained in *Land Operations 2021*.

Clearly, the realization of an effective army force employment concept is an ongoing process. Accordingly, and as that concept moves ahead, we must continue to consider the merit of the ideas that supported and informed it. Such an assessment must proceed in a spirit of openness, but at the same time with a critical eye. At stake is the very relevance of tomorrow's Army. Only by engaging in enlightened discussion and debate will we ensure that the Army of Tomorrow is capable of effectively meeting the threats and challenges we are likely to confront in the years ahead.

J.D.E Crosman
Colonel
Director of Land Concepts and Designs

Introduction

As the 21st century unfolds, Canada continues to face an international arena marked by uncertainty, volatility and risk. While many threats have receded, others have grown in importance, and still others have arisen. The threats we now face are complex and often asymmetric in nature.

It is within this uncertain context that the land force must continue to operate to meet Canada's national security needs and expectations. However, this entails an inherent requirement to do so not only in the short-term but also in the long-term. As such, the Army must work towards a fuller understanding of the character of the future security environment and its implications for armed conflict. Moreover, it must foster operational concepts and doctrine that are clear, relevant and forward-looking. Finally, it must seek capabilities, such as optimized force structures, that ensure its continued effectiveness in the operational environment at home and abroad.

To mitigate against the unpredictability of future conflict and prepare the Army for the challenges that it might face in the future, the Director General of Land Capability Development—now Chief of Staff Land Strategy (COS LANDSTRAT)—was tasked to produce a force employment concept for the Army of Tomorrow. This document, entitled *Land Operations 2021: The Force Employment Concept for the Army of Tomorrow*, was formally endorsed by the CLS in February 2007 and will act as the guide for land force development through to 2021.

The *Force Employment Concept* (FEC) is ambitious and forward thinking but at the same time well grounded in the lessons that we have captured from today's operations. In essence, it is a conceptual guide, from which force development must evolve, acknowledging where we are, what we have achieved, and what we must do to ensure continued success in the future.

The FEC is also reflective of considerable work and in-depth study of the many ideas that it advances. Such study not only provides the intellectual foundation of the concept itself, but the initial step in continuing efforts to further develop and elaborate its many ideas so as to ensure that it reaches effective fruition.

This book details such work. More specifically, it presents the central background studies from which the FEC was produced. As such, it offers a snapshot representing a particular point in time, presenting readers with a record of the state of thought informing the FEC when it was written. More important, it offers essential background into the FEC and greater depth and fidelity on the ideas and subjects that inform it.

The aim is not only to cultivate a greater understanding of the FEC's meaning and rationale, but to stimulate additional dialogue and discussion of the FEC as its elaboration continues to move forward. Only through such a process will the FEC and efforts to implement it realize their true potential in the years ahead.

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Chapter 1

The Future Security Environment

By Mr. Peter Gizewski

> *"While no one can see the future, it is at least possible to indicate a few of the directions that change is likely to take."* —Martin Van Creveld[1]

As the 21st century begins to unfold, Canada finds itself in an international environment marked by considerable uncertainty, volatility and increasingly rapid change. Old familiar "rules of the road" are fading, new ones are just beginning to emerge, and events are unfolding at a speed and pace often exceeding the ability of decision-makers to effectively react. Not surprisingly, many analysts now claim that today's world is more chaotic and unpredictable than at any other period in history.

Nowhere are the challenges more evident than in the spheres of national security and defence policy. While the threat of global war has seemingly disappeared, many dangers linger and new challenges are fast emerging. The dangers of regional conflict—both ongoing and potential—the proliferation of weapons of mass destruction (WMD) and threats posed by irregular strife and trans-national terrorism not only endure but in some cases are growing stronger. Problems of state failure and international organized crime also persist. And prospects for the conduct of electronic and information warfare (e.g., "cyber-terror") are on the rise.

Demands on land forces have been especially pronounced. In the case of Canada's army, six long years in Afghanistan attest to an operation the complexities and dangers of which have not been experienced since the Korean conflict. The ongoing United States-led war in Iraq, the tragedy of Hurricane Katrina and recent strife in Darfur, Lebanon and Sierra Leone similarly underline the enduring significance of today's land forces and the challenges that they can, and must, confront.

Whether the present environment represents an anomaly or in fact "the shape of things to come," is unclear. The future is ultimately unknowable, and history—despite all the insights it may provide into the world and its workings—rarely, if ever, repeats itself completely. Accordingly, any attempt to predict what the future security environment will look like and the threats and challenges it may hold is a daunting task.

Still, attempts to understand and, if possible, anticipate future challenges are essential for effective military planning. This is especially true in the case of land forces, which continue to represent the most direct military means of controlling territory and those that inhabit it and which generally incur the majority of risk in doing so. Indeed, given the demands and inherent dangers that land operations frequently confront, informed security assessments are a must. In their absence, not only is any realistic determination of the character and level of resources needed to meet future challenges impossible, but the dangers stemming from the threats

1 Martin Van Creveld, *The Transformation of War* (New York: the Free Press, 1991), p. 198.

that ultimately arise will likely increase. To this end, the discussion that follows identifies the key trends now evident in the international system, their potential impact on the future security environment, the nature of the potential threats and challenges they pose, and their implications for military forces in general and Canada's land force in particular.

Key Trends

If recent experience demonstrates anything, it is that the security environment is characterized by high volatility and uncertainty and will experience continual, often rapid, change in the years ahead. This makes prediction difficult. And it confounds military planning.

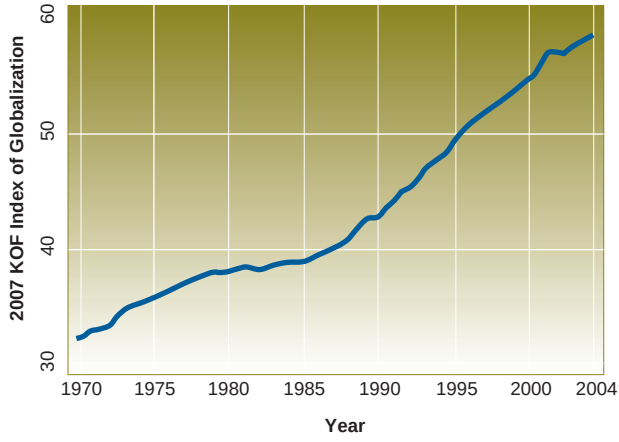
Still, some broad, highly interactive trends are clear. These trends offer an indication of the basic character of the threats and challenges likely to be encountered in the years ahead as well as the general contours of the forces and approaches required to address them.

Globalization

The term globalization refers to the increased mobility of goods, services, labor, technology ideas, information and capital throughout the world. While not a new development, this process has increased dramatically with the advent of new technologies, most notably in the area of telecommunications. In fact, the growing interaction which globalization is facilitating continues to revolutionize the international system. Not only has it worked to integrate national economies but whole societies, dramatically heightening the extent and pace of the flow of ideas, capital and goods and services within and between societies (Figure 1-1).[2]

2 Insightful discussions of globalization and its impacts can be found in Thomas L. Friedman, *The Lexus and the Olive Tree* (New York: Anchor Books, 2000), David Held, Anthony McGraw, David Goldbatt and Jonathan Perraton, *Global Transformations: Politics, Economics and Culture* (Stanford: Stanford University Press, 1999), Robert Keohane and Joseph S. Nye, "Globalization: What's New, What's Not (and So What?)," Foreign Policy, Spring 2000, pp. 104–119, and Martin Wolf, "Will the Nation-State Survive Globalization?" Foreign Affairs, January/February 2002, pp. 178–191.

Figure 1-1: The Development of Globalization Across the World[3]



Source: Swiss Institute for Business Cycle Research and Swiss Federal Institute of Technology, *KOF Index of Globalization* (Zurich: Swiss Institute for Business Cycle Research; January 2007), p. 1.

Such "interconnectedness" increases interdependence and encourages participants to adopt a shared stake in the continued welfare of the system and its parts. By creating greater uniformity across cultures and societies, it may also promote greater unity and openness. Indeed, to the extent that the benefits of globalization tend to favour open markets and societies, incentives to adopt more democratic, and arguably more benign, forms of governance may rise.

Yet, by eroding state sovereignty, the process has also heightened societal vulnerability to outside threats. External events and methods of attack ranging from cyber-warfare to physical assault pose increased potential for massive societal disruption. And growing access to information and technology is dramatically heightening the potential, both among state and non-state entities, to acquire the means by which to succeed (e.g., weapons of mass destruction and their means of delivery). Meanwhile, increased accessibility to global travel heightens risks of terrorist infiltration and the spread of disease to open societies.

Beyond this, forces of globalization may fuel a backlash, either among those who are largely excluded from sharing in its material benefits or from societies and cultures threatened by the norms and values that it promotes. In the near term, violent protest, increased government

3 The KOF index measures globalization on a scale of 1–100 and is based on a three-point index measuring economic, social and political globalization using 25 variables. The economic dimension of globalization includes long distance flows of goods, capital and services as well as information and perceptions that accompany market exchanges. Along with actual trade flows and foreign investment, it captures the degree to which a specific country restricts capital and trade flows. The social dimension measures the spread of ideas, information, images and people. And the political dimension captures diffusion of government policies. Results depicted in the above chart are based on an assessment of 122 countries for the period 1970–2004. For additional detail on variables and methodology, see KOF Index of Globalization Website at http://globalization.kof.ethz.ch/ as well as Axel Dreher, "Does Globalization Affect Growth? Empirical Evidence from a New Index," *Applied Economics* Vol. 38, No. 10, pp. 1091–1110.

repression and growing intolerance and hostility toward Western institutions, influence and presence abroad represent just some of the potential results.[4]

In Canada, a number of these dangers are already apparent. In the wake of the terrorist attacks of 11 September, 2001, politicians and policymakers struggle with perceptions that porous national borders are creating opportunities for terrorist infiltration and the use of Canadian territory as a potential launching point for asymmetric assaults against the United States. Others worry that Canada may offer a safe haven under which trans-national organized crime may flourish. Outbreaks of Severe Acute Respiratory Syndrome (SARS) and bovine spongiform encephalopathy (popularly known as mad-cow disease) underscore varied dangers flowing from the migration of disease. And globalization protests in a number of major cities over the past few years suggest rising public awareness and sensitivity to the political, economic and social injustices which globalization breeds, along with a greater willingness to engage civil disobedience to combat globalization.

Future impacts may be even more profound. Ultimately, globalization processes may work to fundamentally alter Canada's domestic social fabric, and waves of immigration may gradually change both the cultural and linguistic mosaic of the country. Alterations in official language policy and in attitudes toward international affairs could follow. One result could be a further decline in Canada's American and/or European focus toward another, perhaps more "Asia–centric" perspective.[5] As interests and loyalties change, alterations in the character of foreign and defence policy would likely shift as well. Whatever the ultimate impact, however, the ability to remain aloof from the changes generated by the globalization process is bound to dwindle, both in Canada and elsewhere.

Rapid Scientific and Technological Innovation

The past decade has seen a marked increase in the pace and potential implications of scientific and technological innovation. Advances in areas such as information technology, biotechnology, "smart" materials and nanotechnology are occurring at an exponential rate, with potentially revolutionary consequences for humanity.

Such innovations promise a range of benefits in the quality of life, including significant eradication of disease and illness, increased human longevity and freedom from want and hunger. Changes in industry are apt to be equally profound. Increased computing power and the development of new improved materials will likely generate a dramatic improvement in the speed and quality of production.

Yet dangers may arise as well. Inequitable access to advances in health and medicine may fuel tensions between rich and poor in both the developed and developing world. In fact, novel techniques such as cloning, stem cell research and germ-line engineering raise the spectre of a new class system, differentiated by those possessing the ability to enhance

4 Longer term trends may see globalization take on a less Western character as its components extend to other societies and cultures, particularly in Asia. For a discussion of the possibilities, see *Mapping the Global Future, Report of the National Intelligence Council's 2020 Project* (Pittsburgh, PA: Government Printing Office, December 2004), especially pp. 27–29.

5 This is not to say that Canada has not already focused attention on the Asia-Pacific region. On this point, see, *inter alia*, Kurtis Simpson, "Pacific Paradox: Canadian Foreign Policy in Korea, Vietnam and the PRC, 1947–70," unpublished Ph.D. thesis, York University, 1995.

themselves and their offspring via such methods and those lacking the means, or will, to do so. Ultimately, such developments may even ignite new domestic and international conflicts, pitting advocates of such innovations against a growing neo-luddite movement. Notably, debate over the moral, ethical and philosophical implications that such technologies raise is on the increase. As they mature, controversies will doubtlessly intensify.

Radical changes are also underway in the military sphere, with recent years witnessing ever-greater integration of information management systems and advanced technologies into military organizations. Examples include enhanced sensing equipment and improvements in the precision of weaponry. Such developments, along with strides in the areas of non-lethal weaponry and robotics, raise possibilities for the creation of forces that, if properly employed, may work to reduce considerably the civilian casualties that often accompany the use of force. Accordingly, force employment may become more humane and accord more closely with widely held principles of proportionality and non-combatant immunity.[6]

However, other innovations may produce precisely opposite effects. Work on highly powerful volumetric devices (i.e., enhanced blast, thermobaric and fuel-air explosives), along with growing interest in the creation of electromagnetic weapons, may result in changes which nullify the precision targeting and scalability of effects inherent in other technologies. In fact, developments in biotechnology hold the potential for engineering diseases capable of wiping out entire peoples.[7] Innovations elsewhere point to weapons that kill even faster. For instance, advances in laser technology will eventually make possible the capacity for near-instantaneous destruction in the form of directed energy weapons (DEW).

At present, the lion's share of such innovation resides in the West, in the United States in particular. Yet given ongoing processes of globalization, possibilities for greater access to such technologies elsewhere, by friend and foe alike, are increasing, raising potentially profound issues for future stability both regionally and globally.[8]The moral-legal issues that could arise, if and when such technologies are adopted, will be equally far-reaching.

Broadly speaking, Canada's stake in such developments mirrors those of the West generally, both in terms of the threats and opportunities which scientific and technological innovation poses. In fact, a concerted effort to adapt to the increasing pace of innovation and the potential opportunities it presents is essential, particularly in the security realm. Absent greater efforts to tap into new defence related innovations or to match procedures governing the acquisition and procurement of essential equipment to evolving technological realities, the Canadian Forces and Canada's value as an ally may become increasingly anachronistic and irrelevant as time goes on.

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6 Obviously, the benefits promised may be highly dependent on intent. For instance, while innovations in robotics may be employed as a means of accomplishing military missions while preserving life, growing access to such technology could offer new and relatively inexpensive means of destroying it. Indeed, in the hands of terrorist groups, such devices could eventually reduce the need for suicide bombers.

7 Indeed, recombinant DNA technologies (i.e., gene cloning) are already raising the theoretical prospect of weapons capable of wiping out specific ethnic and racial groups. As such, genocidal possibilities cannot be discounted. For critical assessments of such threats, see Raymond Zilinskas, ed., *Biological Warfare: Modern Offense and Defense* (Boulder: Lynne Rienner Publishers, 2001) and Joshua Lederberg, ed., *Biological Weapons: Limiting the Threat* (Cambridge: The MIT Press, 1999).

8 Notably, such innovations are already raising fears concerning an extension of military competition to cyber-space and outer space.

Shifting Power Balances

The abilities of technologically advanced democracies to decisively influence the international agenda will endure for the foreseeable future. And while differences between such nations exist in a variety of areas, organizational and institutional developments suggest that their economic, political and military integration is increasing (e.g., NATO expansion, World Trade Organization [WTO], the European Union [EU] and North American defence integration).

Nonetheless, challenges to the interests of the United States and other like-minded countries will continue to arise. For instance, opposition to Washington's support of Israel will continue to represent a source of armed conflict both in the Middle East and elsewhere. And, to the extent that such unrest occurs, reliable United States allies will be essential, both for ensuring the stability of post-conflict environments and, more broadly, to help provide the international legitimacy required for intervention.

Whether allied solidarity will be sufficient to ensure that challenges encountered are effectively addressed is unclear. In fact, allies may well differ, both in terms of threat assessment and in the approaches and tactics they favour for insuring security. Accordingly, the ability of collective defence and security institutions to address future threats and challenges will vary. Much will depend on the ability of Western nations to seek out like-minded states and build ad hoc coalitions of the willing. Nevertheless, the chances of mounting a strategically *decisive* challenge against the United States and its allies, in the Middle East or elsewhere, will remain low in the near term. And the prospects for systemic (i.e., global) war are even more unlikely.

Over the longer run, however, the dominance of the United States and other like-minded countries is likely to grow more tenuous. By the next decade, the interests and policies of the United States and its allies may increasingly come into conflict with the growing and at times extra-regional ambitions of emerging regional hegemonies (e.g., China, India and Russia). In addition, well-armed rogue or "problem" states (e.g., Iran and North Korea) could seek to resist—either through threats of direct attack or, more likely, through sponsorship of terrorist activity—United States encroachments in areas deemed crucial to their security. Results could range from the declining influence of the United States and like-minded allies, to growing disunity and insecurity. Regional conflicts could proliferate, and ongoing globalization will likely ensure that the economic, political and military consequences of such strife will extend well beyond the initial protagonists. Throughout, forces of globalization promise to heighten the dangers that such confrontations pose, increasing possibilities for the diffusion of weapons and key weapon-related technologies, including weapons of mass destruction.

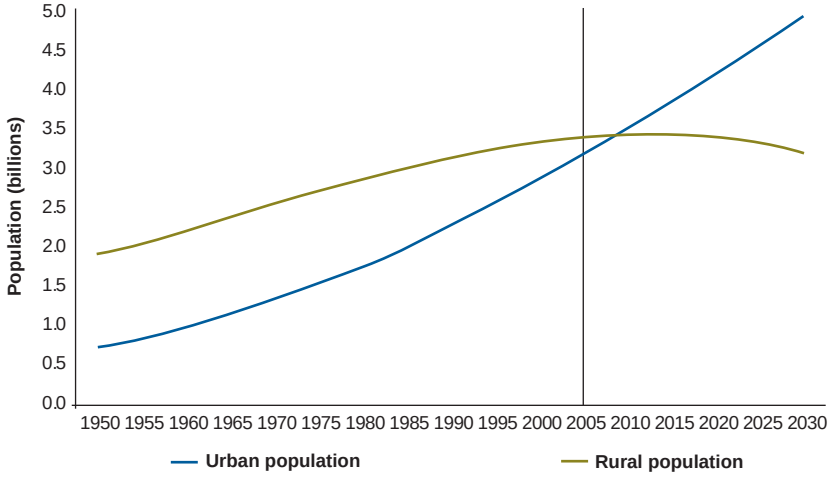
The military power of the United States and its allies will be sufficient to counter most threats. Yet, as time passes, the ability of these states to bear the diplomatic, economic and military burdens of such action is likely to decline. Both the need for fiscal responsibility along with growing domestic and international sensitivity to casualties (both military and civilian) will ensure that the ability to justify military involvement and military action will become ever-more important and difficult, particularly in cases in which core national interests are perceived as

not at stake.[9] Whether policymakers will be capable of continuing to justify military involvement and action, however, remains to be seen. In the event that they cannot, the hegemony and global presence of the United States and its allies is likely to gradually recede, all the while giving way to an international system increasingly characterized by multiple centers of power.

Demographic Pressures

Additional pressures will arise from demographic shifts. In the developing world, trends indicate continued population growth and rapid urbanization (Figure 1-2). It is estimated that over 95% of the projected increase in world population will occur in poorer (i.e., developing) countries, nearly all in rapidly expanding urban areas (Figure 1-3). In fact, more than one-half of global population will be urban by 2015.[10]

Figure 1-2: An Urbanizing World: 1950–2030

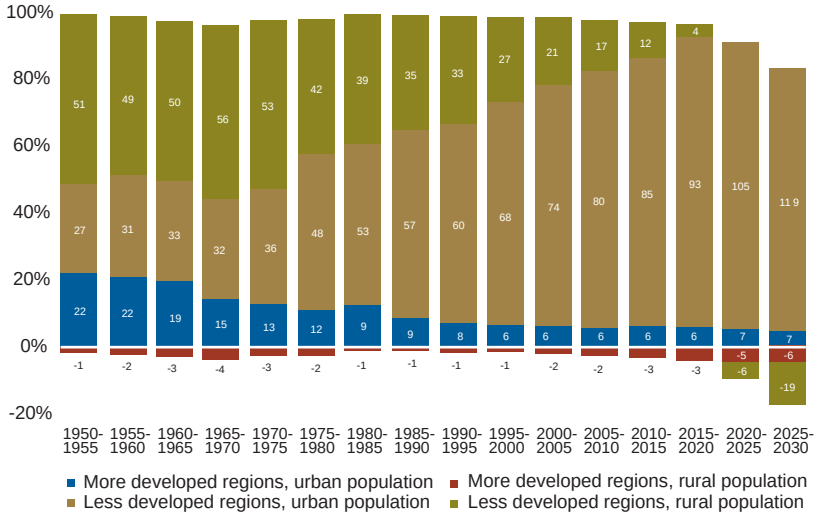


Source: United Nations, Department of Economic and Social Affairs, Population Division (2006). World Population Prospects: The 2005 Revision. Working Paper No. ESA/P/WP/200.

9 Some analysts contend that one of the key features of the emerging international system is the growing importance which moral principle occupies in relations between states. See for instance, Philip Zelikow, "The Transformation of National Security: Five Redefinitions," *The National Interest*, Spring 2003, pp. 20–23, and Leslie H. Gelb and Justine A. Rosenthal, "The Rise of Ethics in Foreign Policy: Reaching a Values Consensus," *Foreign Affairs*, May-June 2003.

10 As reported in Central Intelligence Agency, Global Trends 2015: A Dialogue About the Future with Non-Governmental Experts (Washington D.C.: Central Intelligence Agency, December 2000).

Figure 1-3: Contribution of Rural and Urban Population Growth to Total Population Growth 1950–2030



Source: United Nations, Department of Economic and Social Affairs, Population Division (2006). World Population Prospects: The 2005 Revision. Working Paper No. ESA/P/WP/200.

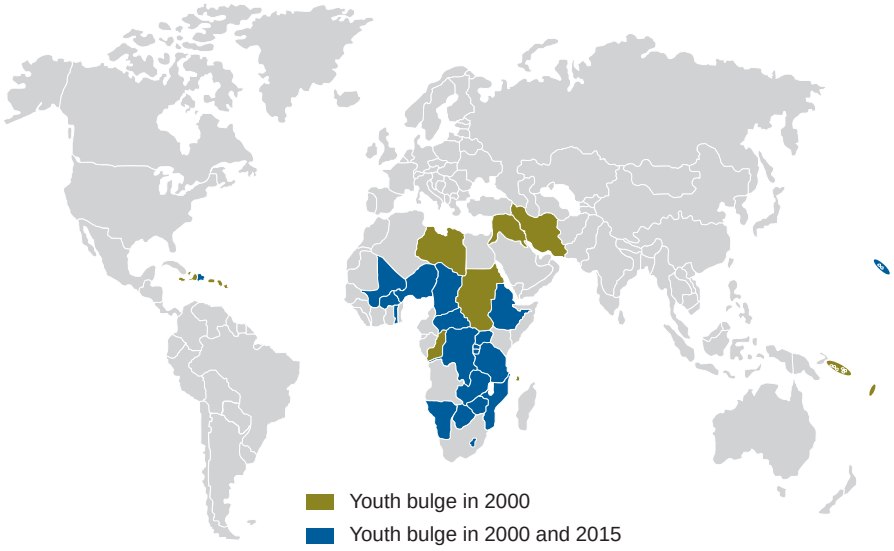
Such increases can place enormous stress and strain on host societies and the regimes that govern them. Urban areas tend to be especially hard-hit, as natural growth combines with significant in-migration to magnify population pressures and overwhelm available services and infrastructure. Already, an estimated 25 to 50 percent of urban dwellers in developing countries live in impoverished slums with little or no access to water and sanitation. Many regions are not likely to experience much relief in the years ahead.[11]

Particularly in the Middle East, Sub-Saharan Africa and South Asia, such forces will continue to strain scarce resources, sowing seeds for rising poverty, disease and instability along the way. One result may be increased civil unrest and internal wars. Another may be humanitarian crises. Still another could be alterations of regional power balances to an extent that could eventually increase inter-state tensions and perhaps even raise the prospect of war due to, e.g., trans-national refugee flows and/or the state weakness that overpopulation may help to generate.[12]

11 See, Central Intelligence Agency, *Long-term Global Demographic Trends: Reshaping the Geopolitical Landscape* (Washington D.C.: Central Intelligence Agency, July 2001) and Brian Nichiporuk, *The Security Dynamics of Demographic Factors* (Santa Monica CA: RAND, 2000).

12 In the future, states in the Middle East and Africa may be especially vulnerable to demographically induced instabilities. Both regions are experiencing rapid urban growth. And, in future, both are expected to exhibit a significant youth cohort (i.e., percentage of population 15–29 years of age), a segment of the population which generally demands greater opportunities for employment and access to resources than others.

Figure 1-4: Youth Bulge in 2000 and 2015



Source: Central Intelligence Agency, Global Trends 2015: A Dialogue About the Future with Non-Governmental Experts (Washington D.C.: National Foreign Intelligence Council, December 2000), 33.

A significant growth in the youth cohort (a "youth bulge" of 15–29 year olds) could well magnify problems, placing particularly high demands on host states for employment and essential services (Figure 1-4). Left unaddressed, such demands will fester and lead to increasing disenchantment with the status quo—conditions which could ensure ready recruits for groups bent on overturning it. In fact, significant youth cohorts contributed to political unrest and civil strife in Algeria, Sri Lanka, Turkey, Iran, Northern Ireland and Gaza. And empirical evidence indicates that during the 1990s, countries marked by high youth bulges (i.e., more than 40 percent of the total adult population) were 2.3 times as likely to experience an outbreak of civil conflict as those with smaller proportions of youth.[13]

An aging West is faced with its own demographic challenges. Demographers increasingly warn that declining populations threaten a significant reduction in tax revenues at the same time that demands for key social services will be rising (Figure 1-5).[14] The impact, both for domestic and foreign policy, is likely to be profound. Dwindling populations may well generate greater reliance on technology as a substitute for manpower, with efforts toward automation

13 As reported in Richard P. Cincotta, Robert Engelman and Daniele Anastasion, *The Security Demographic: Population and Civil Conflict After the Cold War* (Washington DC: Population Action International, 2003), p. 48.

14 Detailed examination of the implications of aging on the international system can be found in Richard Jackson, *The Challenge of Global Aging: How Demography Will Reshape the World of the 21st Century*, CSIS Global Aging Initiative, White House Conference on Aging, July 20, 2005; available at: www.whcoa.gov/about/policy/meetings/Jackson.ppt. See also Peter G. Peterson, "Grey Dawn: The Global Aging Crisis," *Foreign Affairs*, January/February 1999, pp. 42–55. For an examination of the implications of an aging population for Canada, see James Kwok, "Over the Hill: Canada's Demographic Challenge," *Harvard International Review* Vol. XXIX, No. 1 (Spring 2007), p. 8.

becoming especially prominent. Pressures to liberalize immigration and refugee policies may also increase as the need for able-bodied workers and an expanded tax base rises. Alternatively, concerns over national identity and security may work to temper openness, generating greater efforts to provide foreign aid as a means of checking immigration flows and/or greater internal policing and surveillance of those admitted into receiving nations.

Figure 1-5: Economic Costs of an Aging Population

Graying means paying more for pensions and health care		
Public spending on pensions and health-care benefits (percentage of GDP)		
	1995	2030 (official projection)
United States	10.5	15.5
United Kingdom	10.5	17.0
France	17.6	25.8
Canada	12.6	22.5
Japan	11.5	23.1
Germany	17.3	28.8
Italy	19.7	33.3

Environmental Degradation and Resource Scarcity

Scarcities of both renewable and non-renewable resources will magnify problems.[15]

In light of forces such as climate change, population growth and rampant urbanization, many developing countries will see significant degradation and depletion of cropland, forests, and fresh water supplies—a situation likely to increase poverty, famine and disease.[16] Once again, national governments will come under pressure, and prospects for societal instability will grow. Developing nations in Sub-Saharan Africa, the Middle East and South Asia will be especially hard hit, with societies in each region facing crucial deficits in renewable resources such as cropland, timber and fresh water.

An inability to cope with such realities will doubtless feed state weakness, economic decline and societal instability. Indeed, recent research conducted by the Fund for Peace and the Carnegie Endowment for Peace indicates a strong correlation between state stability and

15 Such scarcities may be supply induced (owing to declining availability of the resource itself), demand induced (stemming from rising resource consumption) or structural (a result of unequal access to the resource itself). Most often, however, they arise as result of a complex interaction featuring all three processes. For a systematic examination of the links between environmental scarcity and conflict, see Thomas Homer-Dixon, *Environment, Scarcity and Violence* (New Jersey: Princeton University Press, 1999) and Thomas Homer-Dixon, *Ecoviolence: Links Among Environment, Population and Security* (New York: Rowman and Littlefield, 1998).

16 Indeed, the threat of climate change is now viewed as especially damaging, acting as a "threat multiplier" in fragile regions. Along with other factors mentioned here, it can exacerbate conditions that lead to failed states—the breeding grounds for extremism and terrorism. The potential impact on food output is especially troubling. As Homer Dixon notes, in semi-arid regions, where water is already scarce and cropland overused, climate change can devastate agriculture. In fact, there is some evidence that warming's effect on crops and pastureland is a cause of the Darfur crisis. See, Thomas Homer-Dixon, "Terror in the Weather Forecast," *New York Times*, 24 April 2007, at http://www.homerdixon.com/articles/20070424-nytimesterrorintheweatherforecast.html.

environmental sustainability.[17] Environmental shortfalls may even help fuel, albeit indirectly, the onset of armed conflict either in the form of clashes between key societal groups contesting access to scarce resources or through direct challenges to regime authority.

Water scarcity promises to pose an especially acute challenge (Figure 1-6). According to the United Nations, "more than one billion people on Earth already lack access to fresh drinking water."[18] Today, one person in six lives without regular access to safe drinking water. Over twice that number, 2.4 billion people, lack access to adequate sanitation.[19] By 2025, it is estimated that approximately 48 countries, containing roughly 3 billion people, will face freshwater shortages.[20] About 20 countries in the Near East and North Africa will be especially vulnerable, with current projections indicating that water supplies could be depleted entirely by 2100 if per capita consumption and excessive use are not controlled.[21] In fact, the capacity to control access to this resource in these and other areas (e.g., Central Asia, South Asia and Latin America) may not only come to represent a key source of power but a basis for future conflict.

Developed countries will generally be less directly vulnerable to such challenges, particularly in the case of renewable resources. Yet they will by no means be immune. Some developed nations may see significant shifts in economic and commercial activity, as global warming increases access to and activity in some regions (e.g., Canada's Arctic) while decreasing the utility of others. Concerns over security may well follow.

Beyond this, environmental decline in the developing world may generate indirect impacts, either in the form of increased regional conflict and refugee migration from ecologically stressed regions or in growing demands for humanitarian aid as well as reconstruction and development assistance. Resource rich nations such as Canada may become especially attractive destinations for ecological migrants, either as a permanent home or as a stepping stone from which to gain entry into the United States. And demands for Canadian participation in peace support operations (PSOs) as well as calls on Ottawa for increases in foreign aid budgets could grow. At the same time, rising political sensitivities to the fragility of ecosystems may generate growing pressure for constraints on Western military deployments and activities within regions at risk.

17 See, Fund for Peace and the Carnegie Endowment for Peace, "The Failed States Index 2007," *Foreign Policy*, July-August 2007, p. 61.

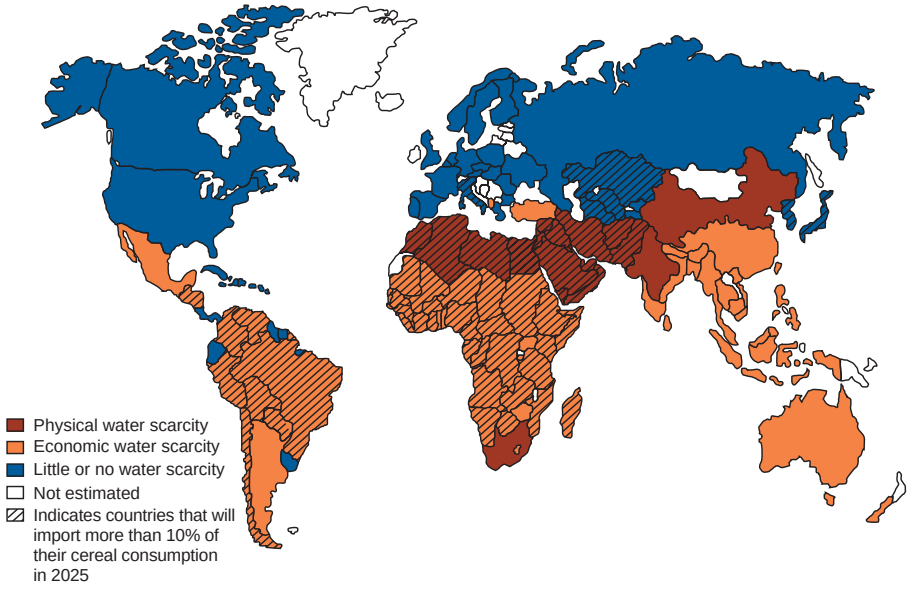
18 As reported in Center for International and Strategic Studies, Global Water Futures: Water Futures at a Glance, (Washington, DC: Center for International and Strategic Studies, 2005) p. 1.

19 Kofi A. Annan, United Nations Secretary-General, *Message from the Secretary General of the United Nations, World, Environment Day*, 5 June 2003, available at: http://www.unep.org/wed/2003/WED03sgmsg.htm.

20 Ibid., pg. 77.

21 Ibid.

Figure 1-6: Projected Water Scarcity to 2025



Source: Central Intelligence Agency, *Global Trends 2015: A Dialogue About the Future with Non-Governmental Experts* (Washington D.C.: National Foreign Intelligence Council, December 2000), pg. 33.

Shortfalls in non-renewable resources may prove even more consequential (Figure 1-7). For instance, as global demand for oil and gas increases in years to come, issues of control and access may pose a growing source of tension between developed and developing nations, as well as within the developing world itself. Admittedly, demand may be somewhat tempered by the development of alternative energy sources. Commercial opportunities for resource rich countries such as Canada may also increase. Notably, however, the ability to fully satisfy growing energy demands through alternative sources is unlikely, particularly as developing nations industrialize (Figure 1-8). Over the next 25 years, oil consumption is expected to grow by 1.4 percent annually and gas by 1.8 percent per year. Moreover, the two combined are expected to account for 60 percent of world energy needs.[22] Accordingly, Middle Eastern oil and other sources of supply in West Asia, Russia, the Gulf of Guinea and North Africa may not only breed growing state interaction, but ultimately, new dangers for turmoil and armed conflict.[23]

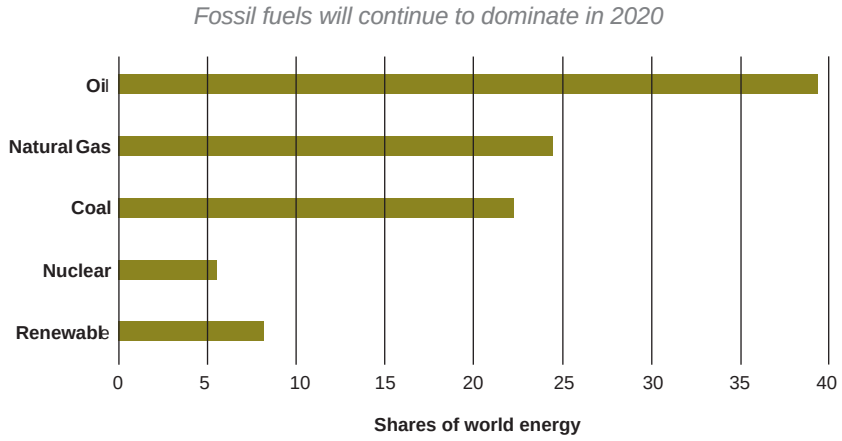
Even efforts to diversify energy supplies may carry risks. As oil and natural gas supplies experience increasing stress, some states may rely increasingly on nuclear power to meet

22 See Remarks by Jaime Spellings, head of Irving, Texas-based Exxon Mobil's corporate planning, in *Report: Global Energy Use To Soar: ExxonMobil Predicts 60 Percent Rise In Consumption Over 25 Years*, Houston, Dec. 13, 2005, available at: http://www.cbsnews.com/stories/2005/12/13/tech/main1123160.shtml.

23 For a detailed study of such possibilities, see Michael T. Klare, Resource Wars: *The New Landscape of Global Conflict* (New York: Metropolitan Books, 2001).

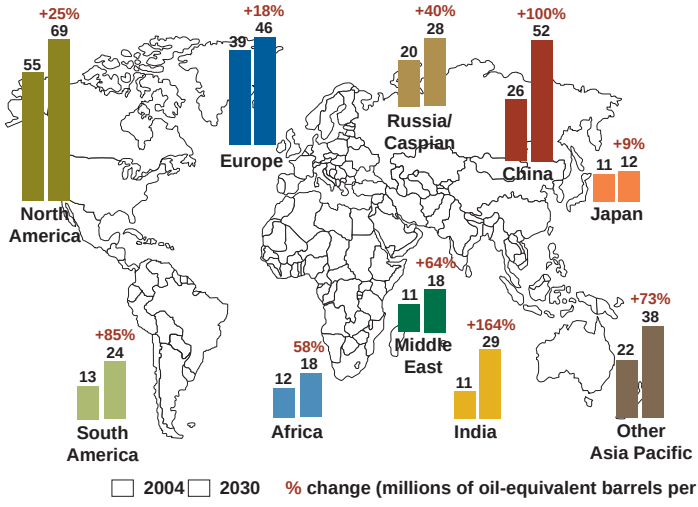
their energy needs. This in turn could serve to "…accelerate nuclear proliferation as countries develop enrichment and reprocessing capabilities to ensure their national security."[24]

Figure 1-7: Projected Energy Consumption to 2020 (By Fuel Type)



Source: National Intelligence Council: *Mapping the Global Future* (Pittsburgh: GPO, December 2004), p. 59.

Figure 1-8: Future Oil Demand: 2030 (By Region/Country)



Source: Exxon Energy Outlook 2004, (as reprinted in United Kingdom Ministry of Defence, *The DCDC Global Strategic Trends Programme: 2007–2036* (United Kingdom: Development Concepts Doctrine Centre, 2007), p. 34.

24 See generally, Organic Consumers Association's *Resource Wars: Climate Chaos & the Forthcoming Crisis in Food Supplies, Water & Farming*, in "The Coming Resource Wars" by Michael T. Klare, Straight to the Source, March 07, 2006; available at: http://www.organicconsumers.org/2006/article_7.cfm.

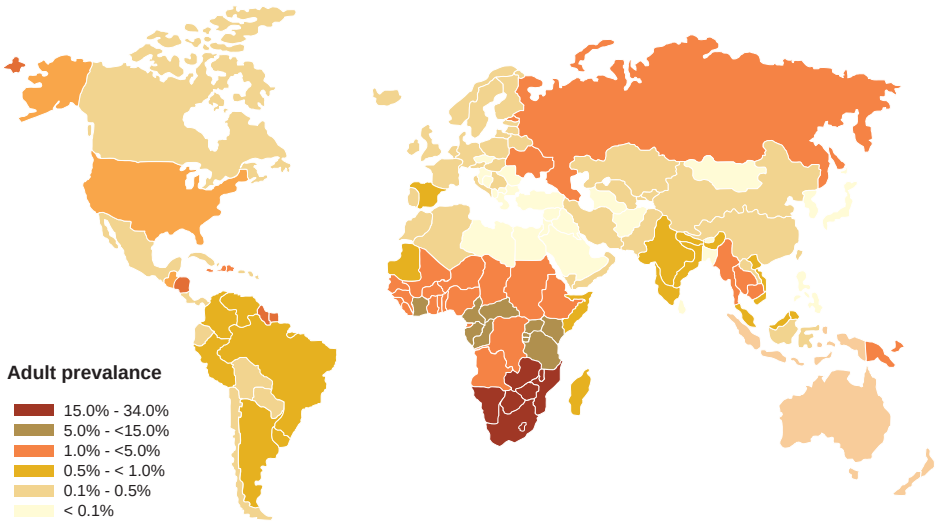
Disease

Meanwhile, endemic disease will pose other dangers. While clearly a longstanding threat to global health, the impacts of disease have been especially prominent in recent decades—a fact perhaps attributable to the arrival of HIV-AIDS as a major force, as well as the ever increasing globalization of transportation systems and the rising mobility of people throughout the world.

Concerns in the developed world are clearly evident, as underscored by SARS and Avian influenza. While troubling, it is nevertheless likely that Western states will continue to achieve inroads against a variety of diseases and will generally be well insulated from their effects as a result of generous health spending and medical advances (e.g., biotechnology).

At the same time, developing nations stand to experience an upsurge in both infectious and non-infectious disease. Given that many have grossly inadequate health care systems as a result of poor funding, infrastructure and education, this is hardly surprising. Consequently, tuberculosis, malaria, hepatitis and HIV-AIDS will continue to increase in spite of efforts being made by the international community to provide aid, and these are likely to account for the majority of deaths in most developing countries, often with destabilizing results.

Figure 1-9: HIV Prevalence Rates Worldwide (2006)



Source: United Nations: *UNAIDS, 2006 Report on the Global AIDS Epidemic* (New York: Joint United Nations Programme on HIV-AIDS, 2006), p. 14.

The scourge of HIV-AIDS is of particular concern, especially in Africa.[25] According to recent estimates, approximately 38.6 million people are already infected with the AIDS virus (Figure 1-9). AIDS alone will reduce economic growth by as much as 1% of GDP per year and consume more than 50% of health budgets in the hardest hit countries. Along with other diseases, this will not only have a destructive impact on families and societies but contribute to an increase in poverty, crime and instability. Beyond this, it will also pose significant health risks to international expeditionary forces involved in the regions affected.

Weak and Failed States

The presence of failed and failing states throughout the international system not only persists but in some regions (e.g., Africa, the Middle East) will likely increase in the years ahead. An arc of frail and failing states already runs unbroken west from North Korea through Central Asia, the Middle East and Angola.[26]

Such states usually have tenuous links to the benefits of globalization. They are also generally characterized by incomplete control over their national territories, an inability to provide basic services to their populations, a lack of popular legitimacy, weak institutions, an absence of the rule of law and widespread corruption both within and outside of government.[27]

Particularly in the developing world, problems of state failure will persevere, as widespread corruption and concerns such as infectious disease (e.g., HIV-AIDS, tuberculosis, SARS), resource scarcity, famine and economic stagnation continue to tax societies and strain already limited state resources.[28]

The inability of such regimes to govern their societies effectively poses a range of security threats. Generally prone to lawlessness, anarchy and rebellion, such states are prime candidates for humanitarian disaster and the many destabilizing forces that accompany it (e.g., epidemics and uncontrollable refugee flows). They may offer safe havens and bases of support for trans-national organized crime, arms dealers and terrorist groups. Their precarious existence can render both their militaries and the armaments they possess vulnerable to takeover and appropriation by rogue elements in government or by private

25 AIDS has become a major problem not only in Africa but also in India, Southeast Asia, several states in the former Soviet Union and in China. For recent statistics, see United Nations: *UNAIDS, 2006 Report on the Global AIDS Epidemic* (New York: Joint United Nations Programme on HIV-AIDS, 2006), pp. 8–50. See also remarks by John C. Gannon, Chair, National Intelligence Council, Defining US National Security for the Next Generation, Conference on the Role of Foreign Assistance in Conflict Prevention, USAID, 8 January 2001; available at http://www.dni.gov/nic/speeches_definingsecurity.html.

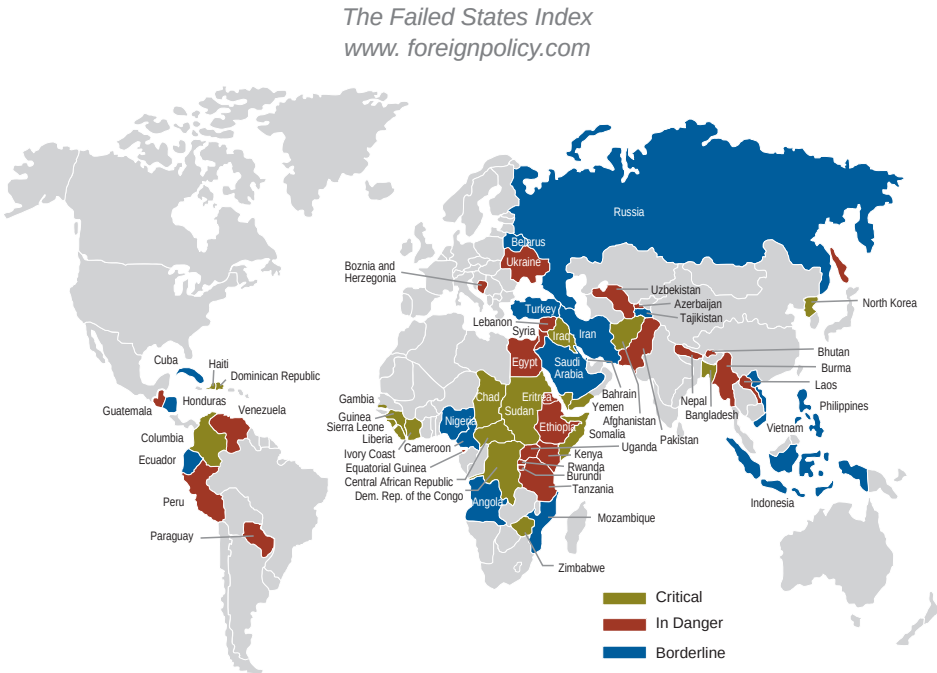
26 Future Security Environment (FSE), North Atlantic Treaty Organization, Draft 1.3, Symposium FSE, 04 Apr. 2006; available at: http://www.act.nato.int/events/documents/06fsesymp/futureenvironment.pdf. The Fund for Peace and the Carnegie Endowment for Peace offers an annual ranking of failed and failing states based on twelve social, economic, political and military indicators. For the most recent version see, Fund for Peace and Carnegie Endowment for Peace, "The Failed States Index," *Foreign Policy* (July/August 2007), pp. 54–63.

27 Banning N. Garrett and Dennis M. Sherman, *Why Non-Globalized States Pose a Threat*, The Board of Regents of the University of Wisconsin System, 2006; available at: http://www.bus.wisc.edu/update/winter03/globalization.asp.

28 Instances of failed and failing states are numerous and span a number of regions. Current examples include the Palestinean Authority and Afghanistan in the Middle East, Columbia and Venezuela in Latin America, Cote d'Ívoire and Liberia in Africa, Pakistan and Sri Lanka in South Asia and Turkmenistan and Uzbekistan in Central Asia.

organizations. To the extent that such states occupy key strategic locations (e.g., Pakistan in the war on terror) or possess crucial resources (e.g., oil in Iraq and Venezuela and nuclear weapons in Pakistan and North Korea) the dangers they pose, both regionally and globally, are heightened.

Figure 1-10: Failed and Failing States: A Recent Picture



Source: Fund for Peace and Carnegie Endowment for International Peace, "Failed States Index," *Foreign Policy* (July/August 2005).

Growing Significance of Non-State Actors

States will continue to represent the key actors in international affairs, but non-state actors will increasingly compete as significant players on the global stage as well. Such actors range from non-governmental organizations (NGOs) engaged in monitoring government performance and policy advocacy, to multinational corporations and private military companies seeking greater profit, to humanitarian organizations engaged in the provision of humanitarian aid and assistance to societies in need. Non-state actors also include organized crime syndicates engaged in trafficking of armaments and dangerous substances, as well as armed irregulars, insurgents, warlords and trans-national terrorist groups intent on undertaking violent action to overturn the status quo.

The latter possibilities are particularly unsettling. The terror bombings of the World Trade Center and the Pentagon on 11 September, 2001 by al-Qaeda operatives dramatically

demonstrated the potential capability of relatively small organizations to conduct operations that can inflict heavy destruction on modern societies.

Near-term possibilities for the occurrence of equally devastating incidents may recede somewhat—a fact owing to heightened vigilance by potential target states and an aggressive international campaign against terrorism. The threat, however, over the longer term may rise again. Ongoing globalization and technological change, exacerbated by the proliferation of readily accessible and relatively cheap technology, are substantially increasing the ability of such groups to organize, function and to infiltrate target societies. Globalization and technological change also facilitate their access to a range of means that enable them to conduct devastating attacks (e.g., high explosives, weapons of mass destruction, etc.).[29] Meanwhile, rogue nations and weak states increasingly offer safe havens and bases from which such groups can operate. Furthermore, the relative anonymity that such groups enjoy makes decisive retaliation against them exceedingly difficult.[30]

Defence against the threats posed by such groups will be increasingly complex and burdensome, especially in open societies such as the United States and Canada. With targets ranging from ordinary civilians to critical infrastructure to key ports and transportation nodes, demands for heightened security will proliferate—and so too will the economic costs of providing it.

Ultimately, the death and physical destruction that such groups could inflict may have even more sweeping implications. Ironically, the need to protect a free society from such attacks may necessitate action that is counter to our culture. Recent efforts in both the United States and Canada to tighten borders and to adopt strong domestic legislation aimed at preventing such dangers have already raised such fears and have generated considerable protest—a reaction which in Canada's case has prompted some retreat from initially proposed legislation (e.g., withdrawal of Bill C-42 and replacement with the *Public Safety Act*, 2002). Yet evidence of terrorist infiltration and activity within Canada and/or more deadly terrorist strikes could reactivate calls for further restrictions on civil liberties in future.

Distributional and Identity-Based Conflict

Both identity and distributional issues (i.e., the growing divide between the "haves" and the "have-nots")[31] will likely remain key drivers of inter and intra-state conflict in the years ahead. Yet conflicts in which identity issues predominate are likely to be especially prominent.

29 For an insightful discussion of the possibilities, see Thomas Homer-Dixon, "The Rise of Complex Terrorism," *Foreign Policy*, January-February 2002, pp. 52–62.

30 In part, such strife represents an ongoing reassertion of historic ethno-national and religious rivalries long suppressed by decades of East-West ideological rivalry. Yet local reaction to the homogenizing effects of globalization and perceived inequities in the distribution of societal benefits among groups involved are also at work. In fact, it is likely that globalization itself serves to both heighten such inequalities and increase awareness of deprivation among those affected—a process that generates a heightened sense of grievance and, ultimately, armed violence.

31 According to recent statistics, more than 1.3 billion people live in abject poverty worldwide, earning only a dollar a day or less per person, and another 2 billion people are only marginally better off. See Robert Svadlenka, "The Emerging Water Crisis and Its Implications for Global Food Security," *World Hunger Year: Innovative Solutions to Hunger & Poverty*, available at: http://www.worldhungeryear.org/why_speaks/ws_load.asp?file=13&style=ws_table.

In fact, issues of identity, ethnicity, culture and belief already represent salient drivers of ongoing strife.[32] In addition to the ongoing and global confrontation between Western secularism and radical Islam, the past decade has witnessed a range of identity-driven clashes such as the Serb hostilities against Kosovar Albanians (i.e., Kosovo), Muslim-Hindu clashes in South Asia (e.g., Kashmir), Hutu-Tutsi strife in Africa (e.g., Rwanda and the Congo) and Christian-Muslim confrontations in Russia (e.g., Chechnya), Western China (e.g., Xinjiang) and Central and South East Asia (e.g., Uzbekistan and Southern Thailand).

Such clashes have tended to be both persistent and highly destructive. In fact, recent experience suggests that parties driven by ethno-nationalist/separatist, religious and quasi-religious beliefs and causes may undertake and prosecute conflict with a degree of purpose and intensity that confounds material-based and generally Western notions of rational action.[33] One result is a tendency on the part of such groups to ignore generally accepted international norms governing the use of force in pursuit of their goals (e.g., ethnic cleansing). Yet another is a degree of immunity their actions appear to have to the standard Western strategies of deterrence (e.g., how does one effectively respond to suicide bombings?).

Dangers will likely endure, if not grow, as the impacts of globalization and technological development extend further. In fact, not only might such processes work to fuel identity-based conflict itself but also the ability of such groups to pursue their goals through ever-more destructive means.

Threats and Challenges—Future Possibilities

The consequences of many of the trends identified above are already being felt throughout the international system. Events such as the dramatic terrorist bombings of 11 September, 2001 (9/11) and subsequent conflicts in Afghanistan and Iraq underline their darker side, dramatically illustrating the dangers posed by rapid and uneven globalization, trans-national terrorism, identity-based international conflict and asymmetric warfare. They also highlight the regional and global dangers posed by failed states and the vulnerability of open and highly urbanized societies to major disruption.[34]

Ongoing trends may also generate other impacts. Depending on the extent of their presence and the character of their interaction, both with the surrounding environment and with one another, a range of alternative security environments are possible. In fact, at least four

32 For an insightful, although highly controversial, examination of this phenomenon, see Samuel P. Huntington, *The Clash of Civilizations and the Remaking of the World Order* (New York: Simon and Schuster, 1997).

33 See Audrey Kurth Cronin, "Behind the Curve: Globalization and International Terrorism, " *International Security* Vol. 27, No. 3 (Winter 2002/03), pp. 30–58, Neil J. Kressel, Mass Hate: *The Global Rise of Genocide and Terrorism* (Boulder, CO: Westview Press, 2002), Robert A. Pape, *Dying to Win: The Strategic Logic of Suicide Terrorism* (New York: Random House; 2005) and Bruce Hoffman, *Inside Terrorism* (Great Britain: Orion Publishing, 1998).

34 In this regard, it can be argued that recent years have witnessed less an alteration in the types of trends and forces at play in the global arena than *in the degree and intensity* at which they are operating.

possible futures, ranging from relatively benign to highly confrontational and unstable, are particularly noteworthy.[35]

Scenario 1—Rough Status Quo

Existing power realities ensure that Western states continue to dominate the international system and the United States continues to fill the role of global hegemon. Globalization and technological innovation continue. But, their chief benefits remain highly concentrated in the developed world, with Western governments and multinationals exerting tight control over operations. Accordingly, Western prosperity increases and integration of developed societies grows.

Elsewhere, conditions are less favourable. While processes of globalization continue to make headway in the developing world, societal benefits are less forthcoming. Many developing countries continue to experience political, economic and demographic stresses. They also remain the locus of the majority of armed conflicts.

Western wealth and global presence elicit some resentment and backlash. Rogue states continue to seek weapons of mass destruction in defiance of Western preferences. Moreover, sub-state actors such as terrorist groups continue to engage in acts of violence against the status quo. Such actions result in some degree of societal dislocation in the West and prompt the adoption of policies allowing greater scrutiny of citizens by affected states leading to an increase in the concerns and debate over the erosion of civil liberties. Nonetheless, a preponderance of economic and military might ensures that rivals are unable to pose significant threats to Western dominance. However, increased sensitivity to civilian casualties imposes constraints on Western military responses. In general, however, technological innovation ensures that Western military action is able to minimize dangers to non-combatants.

Overall, intra- rather than inter-state violence accounts for the lion's share of armed conflict worldwide and occurs primarily in the developing world. Moreover, conflict is largely asymmetric in character (e.g., attacks against civilians, infrastructure and key industries by terrorist organizations, operations against government forces by armed irregulars, low-intensity violence between rival ethnic and religious groups).

Scenario 2—Western Decline and the Emergence of Competing Power Blocs

The US-led West finds its predominance increasingly challenged by the emergence of rising powers and power blocs in coming decades. While processes of globalization and technological innovation remain most mature in the West, an inability to effectively control such processes leads to an increasing diffusion of information, technology and, ultimately, power to various regions of the globe.

35 Efforts to extrapolate the possible worlds that could emerge as a result of current trends are growing. For some recent examples, see Jacquelyn K. Davis and Michael J. Sweeney, *Strategic Paradigms 2025: U.S. Security Planning for a New Era* (Washington, DC: Institute for Foreign Policy Analysis, 1999) and Central Intelligence Agency, *Global Trends 2015:.A Dialogue about the Future With Non-Governmental Experts* (Washington, D.C.: Central Intelligence Agency, December 2000). For a useful effort focusing on the implications of alternative futures for land forces, see Brian Nichiporuk, *Alternative Futures in Army Force Planning* (Santa Monica, CA: RAND Arroyo Center, 2005).

Gradually, regional powers emerge and increasingly cooperate to offset and at times contest the military and technological supremacy and influence of the United States and the West. Such coalitions increasingly harness globalization processes to integrate and gain access to a range of advanced military technologies. In turn, Western presence and influence abroad becomes more tenuous and circumscribed.

Neither the West, nor its competitors, possess the military power, unifying ideology or political culture required to achieve global hegemony. Accordingly, no one state or bloc is fully dominant.

Exclusion of many developing nations from the benefits of globalization and economic and technological progress continues, and backlash is evident, often in the form of ethnic, religious and class conflict. Problems of overpopulation, resource scarcity, civil unrest and state failure also persist. Yet bloc rivalries allow many states to jockey for advantage as competing blocs vie for their support and resources. Threats from non-state actors continue to surface, yet targets of attack are increasingly domestic or regional in nature. Both inter and intra-state conflicts occur, which are both symmetric and asymmetric in character, with the latter remaining most prominent. Notably however, a lack of clear military superiority within any one bloc heightens prospects for inter-bloc war and works to increase the dangers of miscalculation and inadvertent escalation when such conflict occurs.

Scenario 3—An Emerging Global Community

The international system is increasingly characterized by a convergence toward an increasingly liberal-democratic future under Western (or alternatively, great power) stewardship. Forces of globalization and technological innovation spread beyond the developing world and work both to further democratize and homogenize the international system. States and societies across the globe become more tightly integrated, increasingly homogeneous and more open.[36]

Throughout, lead nations and their elites actively work to ensure equitable access to the benefits of globalization processes. Furthermore, international institutions and the rule of law gain greater power and authority (e.g., a strengthened United Nations, creation of an International Court).

Greater access to the benefits of technological advance and globalization works to reduce distributional disparities both within and between states. For instance, access to education in the developing world increases. And this, along with the increased availability of genetically engineered food products and medical breakthroughs, helps to mute the destabilizing societal impacts of population growth. Meanwhile, technological innovation substantially improves military capacities to detect and defend (e.g., enhancements in monitoring systems, strategic and theatre missile defences). Armed conflicts, humanitarian crises and complex emergencies continue to arise. However, as the incentives for resorting to war and acquiring the means through which to prosecute it wane, armed violence is less frequent and intense in character.

36 Recent calls for the creation of a system largely managed by a "concert" of democratic powers are somewhat reflective of the global community scenario outlined above. See, Ivo Daalder and James Lindsay, "Democracies of the World, Unite," *The American Interest* Vol. 2, No. 3 (January-February 2007), available at http://www.the-american-interest.com/ai2/article.cfm?Id=220&MId=7.

Cases of symmetric warfare are rare. And, while the use of armed violence by non-state actors continues to occur, it is increasingly sporadic.

Scenario 4—Increasing Fragmentation of the International System and its Component Parts

Globalization and the march of technology lead to a steady erosion of state power and authority throughout the international system. Slowly, economic, political and military power becomes increasingly diffused and fragmented. Rapid developments in communication and information technology, biotechnology and nanotechnology coalesce to generate growing pressures for new forms of social, economic, military and political organization primarily at the sub-state level.[37]

Despite considerable resistance on the part of states, non-state entities such as cities, distinct regions and even key industries ultimately emerge as the main centres of influence and power. Increasingly, sub-state rather than state units conduct international affairs. Global politics come to resemble a technologically sophisticated version of the middle ages. Conflict, and the potential to wage it, is conducted primarily by loose alliances of sub-state units for a range of purposes (economic and political gain, ethno-cultural predominance, etc.). Broad, unifying themes and ideologies are eclipsed by a wide array of more particularized interests, beliefs and causes. Consequently, popular loyalties are diverse, generally localized and often fickle.

Military organizations are generally small, but the social fragmentation generated by the combined impact of various scientific and technological revolutions ensures that they are numerous and diverse (e.g., professional, mercenary). Furthermore, they are highly sophisticated in character and often possess military capabilities that are exceedingly lethal. Conflict is frequent, often localized in character and features a range of participants.

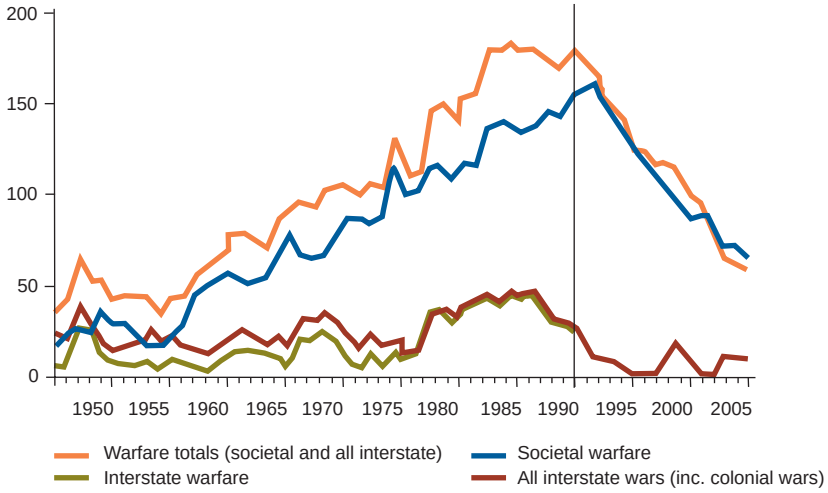
The Near Term: Threats and Challenges to 2021

In short, and depending on how trends interact as well as the direction they take over the long run, a number of alternative security futures are possible—with highly divergent implications for the character, frequency and intensity of armed conflict in each case. That said, such an exercise indicates that regardless of such variation, instability, crises and armed conflict will continue to occur. Indeed, while the frequency, intensity and specific goals of such situations will vary from case to case, such turmoil itself will represent an enduring feature of international politics in any realistic security future.

37 For an argument along similar lines, see Thomas K. Adams, “Radical Destabilizing Effects of New Technologies,” *Parameters*, Autumn 1998, pp. 99–111.

In the near term, some forms of turmoil and instability will nevertheless be more prominent than others.[38] Much will arise in the developing world and will likely be intra-, as opposed to inter-state, in character (see Figure 1-11).[39] Conflict involving trans-national actors and movements will also remain prominent. And civil wars, revolutionary insurgencies and internal rebellions will mark the lion's share of such strife.

Figure 1-11: Global Trends in Armed Conflict 1946-2005



Source: United Kingdom Ministry of Defence, *The DCDC Global Strategic Trends Program: 2007-2036* (UK: Development Concepts Doctrine Centre, 2007), p. 69.

At the same time, future security challenges will not simply end at the water's edge. In an increasingly interconnected, interdependent and information-based international system, lines between the external and the domestic will be increasingly blurred. Climate change, natural disasters and even the flow of goods and people respect no boundaries. And, the ability to operate and interact within networks and share information will increase dramatically in significance, posing both new opportunities and challenges. Accordingly, developments in

38 Studies examining the future character of conflict and its implications for military strategy are plentiful. Particularly insightful works include: Martin Van Creveld, *The Transformation of War*, (New York: The Free Press, 1991); Chris Hables Gray, *Postmodern War: The New Politics of Conflict* (London: The Guilford Press, 1997); Major General Robert H. Scales Jr., *Yellow Smoke: The Future of Land Warfare for America's Military* (New York: Rowman and Littlefield, 2003); Marc Cerasini, *The Future of War: The Face of 21st Century Warfare* (Indiana: Alpha Press, 2002); Col. Thomas X. Hammes, *The Sling and the Stone: On War in the 21st Century* (St. Paul, Minnesota: Zenith Press, 2004); Herfried Munkler, *The New Wars* (Massachusetts: Polity Press, 2005); Michael Evans, "From Kadesh to Kandahar: Military Theory and the Future of War," *Naval War College Review*, Summer 2003, pp. 132–150; Michael T. Klare, "Waging Post-Industrial Warfare on the Global Battlefield," *Current History*, December 2001, pp. 433–437; Colin S. Gray, *Another Bloody Century: Future Warfare* (London: Phoenix House, 2005); and David J. Kilcullen, "Countering Global Insurgency," *Journal of Strategic Studies* Vol. 28, No. 4 (August 2005), pp. 597–617.

39 For a good review of the empirical evidence, see Human Security Centre, *Human Security Brief: 2006* (Vancouver, British Columbia: University of British Columbia, 2006), pp. 1–17. See also Sven Chojnacki, "Anything New or More of the Same? Wars and Military Interventions in the International System, 1946-2003," *Global Society* Vol. 20, No. 1 (2006), pp. 24–46.

the global realm are increasingly apt to have domestic consequences. And the need to provide domestic security may become more pressing and its requirements more complex.

Changing realities on the home front may complicate matters further. For instance, as Canada's population ages and becomes more diverse—ethnically, religiously and culturally—how we view and respond to emerging security challenges may well differ considerably from past practice. In some cases, shifts in the ethno-cultural mix of Canadian society may generate new concerns abroad and thus demands for new external involvements, some of which will be military in nature. And a declining human resource base may necessitate greater reliance on new forms of technology as a means of compensating for shortfalls in person-power.

To be sure, symmetric, "view 1-type" engagements between regular armies will remain a distinct possibility (e.g., Russia-Ukraine, India-Pakistan over Kashmir, PRC-ROC-US over Taiwan, US-North Korea).[40] In general, such conflicts will feature high-tempo, conventional battle utilizing relatively complex technologies between national entities. On the whole, however, such engagements will be less frequent in the immediate years ahead. Indeed, as the cost and risk of such engagements continues to rise, inclinations to undertake such action, as well as the capacity and willingness to sustain its conduct, will dampen.[41]

At the same time, "view 2" or asymmetric conflicts are likely to be somewhat more prevalent.[42] In this regard, challengers will be wide-ranging and could include not only states but a range of non-state actors, including media-savvy trans-national terrorist organizations intent on limiting Western influence and presence in their lands, warlords seeking to retain power and influence over local populations at any price and trans-national criminal organizations ready, willing and able to buy, sell and trade everything from drugs to armaments for their own gain.

Such aggressors will tend to avoid direct engagement of regular forces and instead focus on exploiting societal vulnerabilities and disrupting the course of everyday life in an attempt to erode and eventually undermine the authority, and the will, of state adversaries to fight. Conflict may be protracted in character, and adversaries will generally show little regard for established laws of armed conflict or rules of engagement. In fact, knowing full well the tendency among liberal-democratic governments to be casualty averse, particularly when confronted with conflicts in which linkages to national interest are indirect or tenuous, efforts to maximize civilian destruction, fear and discomfort will often represent a key aspect of their approach. And civilian populations, key industrial and commercial facilities (e.g., financial institutions, power grids) and/or symbols of state power will often represent prime targets for attack.

Assaults could involve weapons of mass destruction and perhaps even exotic weaponry, particularly as technology cascades throughout the international system. Prospects for the

40 See Canada, *Future Army Capabilities* (Kingston: Directorate of Land Strategic Concepts, 2001), pg. 2.

41 Michael T. Klare, "Waging Post-Industrial Warfare on the Global Battlefield," *Current History*, December 2001, pg. 434.

42 As commonly defined, "view 2" conflict envisions nation states opposed by armed bodies that are not necessarily armed forces, directed by social entities that are not necessarily states, fought by people who are not necessarily soldiers. See, Canada, *Future Army Capabilities*, pg. 2.

use of chemical and biological agents by state and non-state actors are especially unsettling. Yet in the near term, tried and true methods such as abduction and arson,[43] along with the adaptive use of low-cost, accessible, off-the-shelf technologies (e.g., purpose-built munitions, improvised explosive devices, rocket propelled grenades), both for enabling plans of attack and for conducting them, will be more likely. So too will be attacks aimed at disrupting critical information systems and key databases (i.e., information warfare).[44]

Regardless of the means employed, however, the character of conflict will increasingly diverge from past experience, as large, set-piece battles between rival armed forces increasingly give way to more fluid, non-linear engagements in which aggression could emanate from a multiplicity of sources, using a wide range of technologies and tactics against innumerable and often non-military targets.

Meanwhile, problems of state failure, resource scarcity and demographic pressure will continue to generate humanitarian crises and complex emergencies. Poverty, disease and civil strife will be all too common. And the challenges associated with restoring order and stability to those nations and regions affected will similarly continue, if not increase. In fact, requirements for humanitarian action, stabilization and reconstruction will often arise in tandem with the prosecution of conflict itself.

Throughout, turmoil will often unfold in environments in which opposition to Western, and most notably United States, influence and presence is on the rise. And sensitivity to casualties, as well as rising expectations regarding their avoidance will likely be acute among general publics, both in Western nations and elsewhere, especially in cases where links to national interests are unclear.

Military Implications

The challenges posed by such a threat environment for Western militaries will be profound. While certain forms of strife and instability will likely be more prevalent than others, the spectrum of potential challenges that could arise will remain wide. The environment will continue to be marked by considerable uncertainty, rapid change and a high degree of complexity. Conflict zones will be highly fluid and multidimensional. Distinguishing friend from foe (or neutral) will be ever-more difficult. And enemies may often be dispersed over a wide geographical area.

Beyond this, future foes promise to be *even more* adaptive than those present today and the threats they pose even more varied and lethal. Globalization and exponential technological change will offer a wide array of actors opportunities to achieve a degree of influence and reach unlike anything seen in the past.[45] This, combined with human ingenuity, will provide

43 Notably, the U.S. State Department's annual survey on terrorism notes that "in 2006 most attacks were perpetrated by terrorists applying conventional methods that included using bombs and weapons such as small arms." See, Daniel L. Byman, "The Rise of Low-Tech Terrorism," *Washington Post*, 6 May, 2007, p. B03.

44 An excellent collection of essays examining the various possibilities is offered in Robert J. Bunker, ed., *Non-State Threats and Future Wars* (Portland, OR: Frank Cass Publishers, 2002).

45 Indeed, increasing access to a wide range of technologies may well enable even non-state foes to possess a degree of reach, knowledge and lethality previously confined only to select nation states.

challengers with an increased capacity to organize, network and mount significant challenges on a range of fronts—moral, political and military.[46]

With greater access to a range of enablers (e.g., cell phones, the Internet, a wide array of weapons and weapon-related technologies), opportunities for adversary mobility, reach and lethality will grow.[47] So too will the capacity of rivals to quickly adapt to Western strategies and capabilities and to exploit Western strengths and weaknesses to their advantage. The result will be an increase in the opportunity for adversaries to prey upon the openness of the democratic system to infiltrate it, the casualty aversion of Western publics to erode their will to engage the threat they pose on a sustained basis and the vulnerabilities of Western information and communication systems either to corrupt them or to appropriate their power for their own purposes.

Within the regions in which turmoil will often originate, moreover, the conduct of armed conflict will often be only part of the challenge, as rampant civil disorder, famine and disease constantly linger in the background and threaten societal collapse as well as the prospect of even greater misery and carnage to come. Indeed, addressing *these* dangers may be as crucial to success and future stability as prevailing on any battlefield. As is increasingly evident today, tomorrow's military contests will be as much about winning "hearts and minds" and gaining respect and legitimacy among surrounding populations as about destroying adversaries.

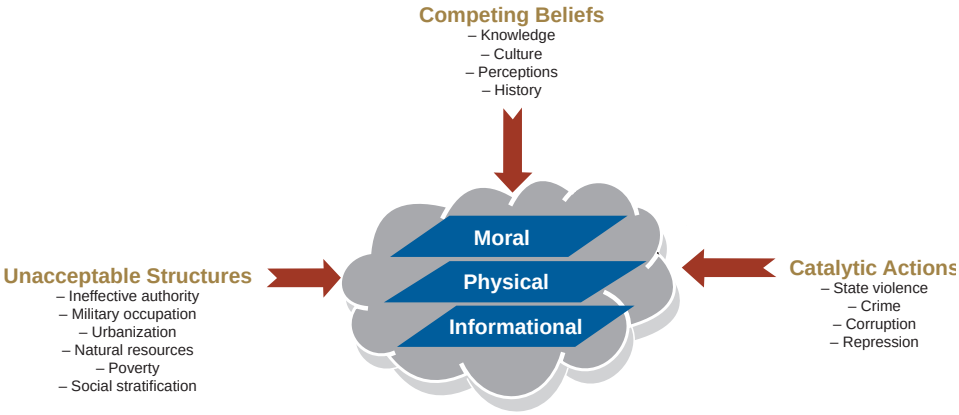
In fact, in an increasingly globalized and interdependent world, the very nature of conflict itself is likely to be more complex, as the three-dimensional web of actions, structures and beliefs that comprise it encompass more actors, more motivations and more varied strategies and means for achieving the goals of those involved.

Throughout, and far more so than in the past, conflict and its conduct will involve less emphasis on its physical and more on its moral and informational components, as contestants engage in a struggle which increasingly focuses on the will of opponents and their societies. The perceptual, psychological and ideational will increasingly eclipse the physical as the chief battleground, and the human dimensions of conflict will be ever more salient and significant.

46 Hezbollah's recent performance "in a set-piece battle with the Israeli military (arguably once, a top notch conventional military) is an excellent example of how non-state groups have radically improved their ability to conduct tactical and strategic operations." See, Peter Singer, The Secrets Of Hezbollah's Success, Sunday, 30 July, 2006; available at: http://globalguerrillas.typepad.com/globalguerrillas/2006/07/the_secrets_of_.html.

47 On this point, see Frank G. Hoffman, "Small Wars Revisited: The United States and Nontraditional Wars," *The Journal of Strategic Studies* Vol. 28, No. 6 (December 2005), pp. 913–940.

Figure 1-12: The Nature of Conflict in the Future Operating Environment



Conflict results from a complex interaction of beliefs, actions and structures in periods of political, economic, and social instability. Resolution of this type of conflict requires an integrated multi-dimensional approach that addresses actions, structures, and beliefs across moral, physical, and informational planes.

Source: Directorate of Land Concepts and Design, *Land Operations 2021: Adaptive Dispersed Operations—The Force Employment Concept for Canada's Army of Tomorrow* (Kingston: DLCD, 2007), p. 5.

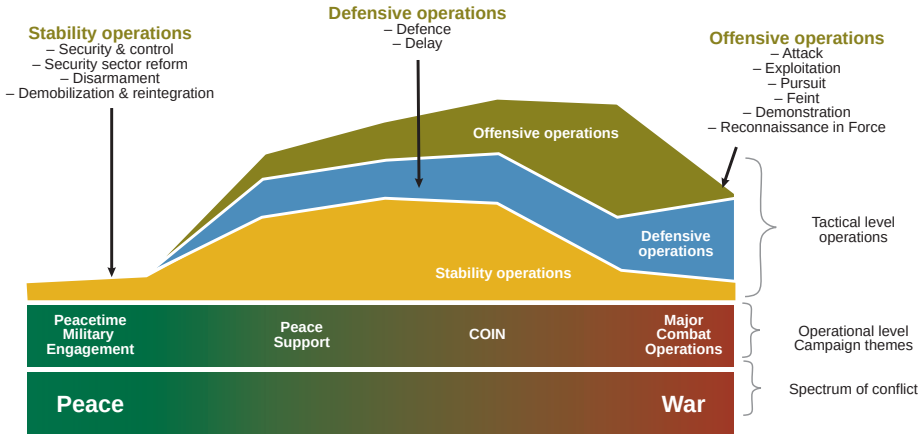
Land Force Requirements

Such an environment and the prospective challenges it poses will ensure the continuing importance of land power as an instrument of national policy in the years ahead. Indeed, many of the situations likely to arise will require the control of territory and people. And armies will continue to represent the most direct military means of achieving this on a sustained basis. In short, the use of land power, i.e., "troops on ground," will be essential if anything resembling decisive control of territory and its inhabitants is to be achieved.[48]

At the same time, the demands for ensuring that such forces are effective will likely be considerable. The potential complexity and the prospective dangers which the future security environment holds will ensure that future land forces must stand ready to undertake operations along a continuum that encompasses offensive, defensive and stability operations conducted along the entire spectrum of conflict. To be sure, major combat operations will focus primarily on offensive and defensive actions and aim at defeating the enemy's forces and/or securing terrain. Yet stability operations will also take place, often in dynamic and complex environments in which tactical objectives are intrinsically linked to longer-term political objectives that may, in turn, be influenced by domestic and international media and public perceptions (Figure 1-13 illustrates the types of actions which may be undertaken during offensive, defensive or stability operations).

48 On the enduring importance of land power in the future security environment, see, Colin S. Gray, *Another Bloody Century: Future Warfare* (London: Phoenix House, 2005), p. 201.

Figure 1-13: The Continuum of Operations



Source: Directorate of Land Concepts and Design, *Land Operations 2021: Adaptive Dispersed Operations—The Force Employment Concept for Canada's Army of Tomorrow* (Kingston: DLCD; 2007), p. 7.

The capabilities needed to effectively meet the challenges posed by the future security environment will be numerous.

External challenges not only increase the need for combat and counterinsurgency operations but also complex stabilization and reconstruction missions in those societies ravaged by man-made and natural disasters.[49] In fact, the complexities of future conflict will heighten the need for Western militaries to fight "the three-block war."[50] Not only must troops be capable of effectively conducting a range of operations (i.e., high intensity combat in one area, stabilization operations in another and humanitarian aid or support in a third) but of quickly and effectively transitioning from one mission to another. Given that missions may even overlap, they must also be capable of conducting a variety of operations simultaneously, often as part of a broader, integrated team.[51]

49 For Canada, this has increasingly ensured that traditional peacekeeping (i.e., the employment of lightly armed observers in support of negotiated ceasefires) has been eclipsed by growing demands for robust peace support, stabilization operations and the need to help reconstruct societies ravaged by man-made and natural disasters. Missions are more complex and dangerous, with troops frequently deployed to regions and countries where there is little peace to keep and where threats are often numerous, multidimensional and intertwined.

50 Indeed, the "three-block war" concept is often described as a growing motif for military operations today and for the foreseeable future. In Canadian doctrine, the term "full-spectrum operations" is used to better capture the essence of the simultaneous conduct of operations by a force across the spectrum of conflict.

51 Afghanistan and Iraq are especially indicative of new realities. In fact, the latter case may represent a template or model of things to come, not necessarily in the sense that future conflict will resemble it entirely but in the sense that it encompasses many of the operations that could be required. Indeed, Afghanistan illustrates the demands of the three-block war, with combat occurring at the same time that humanitarian and reconstruction efforts are being undertaken. At the very least, this suggests that future war will look more like Afghanistan and Iraq than WWII.

Domestically, the unfolding security environment will increase the need for constant surveillance and monitoring of national borders and airspace to guard against possibilities of infiltration and/or attack. And it will demand an improved capacity for consequence management in support of the civil power in the event any domestic emergencies (both natural and human-induced) arise.

Certainly, robust combat capabilities will be essential, particularly in the form of lethal, more precise, agile and net-enabled forces, Special Forces, enhanced capabilities to operate in complex terrain and to shield military systems and personnel and the possession of tactical and strategic lift for rapid deployment into and within theatre. Timely sensing and intelligence capabilities (especially human intelligence [HUMINT]), and effective, robust command and control will be equally crucial. So too will improved capacities to conduct information operations as well as some nation-building to help win "the hearts and minds" campaigns abroad.[52]

A more joint, increasingly integrated and comprehensive approach to future operations will be needed as well. In a world of increasingly complex conflict, military power alone is unlikely to achieve true solutions to the problems that will arise. Rather, lasting solutions will require the effective coordination and cooperation of development, diplomacy and security resources to achieve desired ends. Accordingly, the capacity for militaries to operate in a dispersed fashion and effectively network amongst themselves and with other departments, agencies and organizations will be crucial to success. So too will be the capacity, where possible, to effectively interoperate with other nations (i.e., allied militaries) in a coalition approach.

Yet perhaps the most crucial component for ensuring an effective response to the challenges of tomorrow will lie in the intellectual or conceptual realm. More specifically, it lies in the need to ensure that adaptability, agility and flexibility are central guiding principles and components in the conception, development, design and employment of those capabilities that constitute the military forces of tomorrow. In particular, a capacity to adapt quickly and effectively to unfolding circumstances and operate with a wide array of actors in a dispersed manner, providing a crucial hedge against the unexpected, will represent key components for effective security. Only then will forces be able to maintain their utility in the face of high uncertainty, rapid, often sudden, change and the multi-dimensional threats and challenges likely to characterize the world in the years ahead.

To be sure, some movement along this path is already underway, with most Western militaries currently in the process of developing the capabilities, strategies, tactics and procedures needed to more effectively deal with the threats and challenges of today's complex environment. In this regard, many Western armies, including that of Canada, are pursuing forces that are rapidly deployable and more adaptive, mobile, combat capable and sustainable. They are bolstering capabilities to better ensure security on the domestic front. And they are also making efforts to become more interoperable with allies.

Efforts to practice a more joint, integrated and "whole of government" approach to operations are also evident. Indeed, ongoing operations in Afghanistan offer a case in point. Over the

52 In this regard, linguistic and cultural training will be crucial, particularly for the conduct of counterinsurgency operations. See David J. Kilcullen, "Countering Global Insurgency," *Journal of Strategic Studies* Vol. 28, No. 4 (August 2005), pp. 597–617. See especially pp. 613-14.

course of Western involvement, coalition allies have combined counterinsurgency operations involving Special Forces and regular infantry with broader efforts aimed at stabilization and reconstruction of the country. Military, diplomatic, development and law enforcement personnel are in fact working together in a relatively collaborative, cooperative framework to help realize the Afghanistan National Development Strategy (ANDS) and thus bring stability, prosperity and good governance to the country.[53]

Still much more remains to be done. For instance, notwithstanding attempts to practice an integrated, more "whole of government" approach to operations, recent efforts have largely been ad hoc in character. As such, there is a need to develop clear and accepted institutions, practices and procedures to more fully facilitate the goal.

Furthermore, effective adaptation requires more than new kit or even broad approaches; it requires quality personnel and training to ensure that militaries can cope with a more dangerous, complex threat environment. In environments characterized by the three-block war, requisite skill sets can be high. Militaries must be highly flexible, agile and capable of responding to the unforeseen and expected, quickly and effectively. They must also excel at close combat. And they must be both technologically proficient as well as culturally aware. Put simply, they must be capable of doing *many* things well, often simultaneously and while under enormous pressure. Whether recruitment and training regimes can meet these requirements and meet them to the level needed to persevere in the conflict zones of today remains an open question.

That said, further efforts at adaptation are essential. Absent a coherent and comprehensive approach to security—one reflecting an appreciation of the increasingly multidimensional, dynamic and fluid nature of conflict and one which clearly integrates both military and non-military assets into a logical, coherent framework—threats will intensify and proliferate, and national security will be compromised.

Conclusion

The degree to which Canada's Army will be called upon to address the challenges outlined above remains to be seen. While a recognition and analysis of ongoing trends and challenges provides some guidelines for determining the types of threats that may be encountered in future, continuing uncertainties ensure that the observations advanced must be general. There is no crystal ball from which to precisely determine the challenges that we will confront. Nor, for that matter, is it within our capacity to determine the exact means that will be required to address such challenges as they arise.

Economic and fiscal realities can, and no doubt will, impose additional constraints on the capacity to address future challenges. In light of finite resources and the range of demands increasingly likely to confront governments both domestically and on the international stage in the years ahead, the ability to undertake substantial alterations in force size, composition and structure cannot always be ensured.

53 Here, while success is by no means assured, the experience of "learning by doing" is likely to prove beneficial for the conduct of future operations, offering lessons for future consideration. Already, for instance, it has underlined the benefits of an integrated approach, making it clear that the presence of HUMINT and civil affairs as well as an effective information campaign is critical to achieving success in the stability phase of operations.

Still, in a world of high uncertainty and rapid change, an emphasis on the development of a flexible, adaptive force—one capable of dispersion when required and networked to collaborate effectively with other militaries, departments, agencies and organizations—offers an eminently reasonable course. Pursued as a key transformational goal, such an approach promises an increase in the capacity of forces to adjust to the unexpected and to respond accordingly *whatever* the environment faced and *whatever* challenges may materialize. Indeed, it offers the most logical response to the dangers and challenges likely to materialize in the years ahead.

Chapter 2

Emerging Global Technologies and Trends

By Mr. Regan Reshke

> *Science and Technology can effectively support the Canadian Forces transformation by contributing directly to the advancement of Canadian military capabilities.* —R.J. Hillier, General, Chief of the Defence Staff and Ward P.D. Elcock, Deputy Minister, in a foreword introducing the Defence S&T Strategy, released in December 2006

Throughout history, warfare has been profoundly altered by science and technology.[54] In his analysis of the effect of industrialization and technology on warfare, Patrick Murphy[55] reveals that Europe after 1850 experienced a surge in weapon development. Science and technology contributed to the improvement of most weaponry, including small arms (the breech-loading rifle) and artillery (rifling), yielding vast increases in accuracy and lethality, which altered the way wars were fought thereafter. The very same trends are recognizable today—increasing accuracy, range, firepower, lethality, troop dispersal, information technology-enabled command and control and technological disparities.

Science and technology (S&T) are also the primary drivers of the economies of developed and developing countries. Fifty-eight percent of executives surveyed in the 2005 Economist Intelligence Unit CEO Briefing[56] cited advances in technology as the most critical driver of change in the global marketplace. And, science and technology shape all other driving forces, from demographics to globalization.[57]

54 Science is defined as any system of knowledge that is concerned with the physical world and its phenomena and that entails unbiased observations and systematic experimentation. In general, a science involves a pursuit of knowledge covering general truths or the operations of fundamental laws. Scientific knowledge is a fundamental enabler for the development of new or improved technologies. Thus, the major innovations of future technology, those that will shape society, will require a foundation of strong basic research. Hence, innovation is the key to the future, whereas basic research is the key to future innovation. See, http://www.britannica.com/eb/article-9066286/science Technology is the application of scientific knowledge to the practical aims of human life or, as it is sometimes phrased, to the change and manipulation of the human environment. Technology thus comprises machinery and equipment based on scientific knowledge. Tools and machines, however, need not be material. Virtual technology, such as software, also falls under this definition of technology. Military technology comprises the range of weapons, equipment, structures and vehicles used specifically for the purpose of fighting. It includes the knowledge required to construct such technology, to employ it in combat and to repair and replenish it. See http://www.britannica.com/eb/article-9071527/technology and http://www.britannica.com/eb/article-9110174/military-technology.

55 Patrick Murphy, "The Effect of Industrialization and Technology on Warfare: 1854-1878"; available at http://www.militaryhistoryonline.com/general/articles/effectofindustrialization.aspx.

56 http://www.ukinvest.gov.uk/10481/en_IL/0.pdf. The CEO Briefing, sponsored by UK Trade & Investment, is an annual Economist Intelligence Unit research programme designed to identify the management challenges that face the world's corporate leaders.

57 Several technologies shape demographics. For example, fertility, reproductive and contraceptive technologies influence birthrates, whereas medical intervention and treatments can extend life expectancies. Globalization is also shaped by technology, primarily those pertaining to information and communications technologies.

Certainly, opinions vary as to the key drivers of change for the future. Yet there is broad consensus amongst those who study the future that technology is the primary enabler of social change.[58]

It is important to monitor and understand ongoing and emerging trends, since this helps organizations think about adapting to the future. And, it is imperative that trends pertaining to science and technology be analysed due to their acknowledged status as key drivers. While it is impossible to predict the future, studying the primary factors contributing to change does allow for identification of some of the broad possibilities that lie ahead. Negative possibilities constitute a warning, while positive possibilities can reveal opportunities that should be actively pursued, thus shaping the future.[59]

The examination of technologies and trends undertaken below is wide-ranging, covering both military and commercial systems and their impact on society and the military.

Technological Drivers

According to the Canadian National Research Council (NRC) Renewal Futures Team,[60] three primary transformative technologies will drive global change out to 2020: information and communication technologies (ICTs), biotechnologies and energy and environmental technologies.

The transformative power of information and communication technologies is already under way and is apt to be even more profound by 2020. It is expected that computing power will become ubiquitous and part of the fabric of daily living. The transformative nature of biotechnology, according to the report's authors, will eventually impact most sectors of the global economy. It is suggested that biotechnologies are becoming the most significant S&T area of the current century, with impacts that are expected to exceed even those of information and communications technologies. Energy and environmental technologies are rapidly

58 Though the importance of science and technology is clear, its value and function in society remains a matter of debate since it is hard to anticipate the effects of these changes, and it is not clear whether technology drives a societal change or if it is the other way around. Increasingly, it seems that it is neither one nor the other, but rather a symbiotic connection—technology and society influencing each other's development in incremental steps, sometimes one leading and sometimes the other, but both ultimately progressing.

59 In his study, *Futuring: The Exploration of the Future* (Bethesda, MD: World Future Society, 2004), Edward Cornish compares the study of the future with the grand expeditions of the great European explorers. Military professionals will readily identify with the great explorers' meticulous preparations, their success depending upon having the right equipment, the right supplies, the right team mates and the right training at the moment of need. Cornish identifies seven lessons from these great expeditions that are applicable to the study of the future: prepare for what you will face in the future; anticipate future needs; use poor information when necessary; expect the unexpected; think long term (strategically) as well as short term (tactically); dream productively (creatively innovate); and learn from your predecessors. Ironically, despite the broad parallels between the study of the future and military planning, military professionals dedicate very little effort towards the study of the future.

60 http://www.nrc-cnrc.gc.ca/aboutUs/ren/nrc-foresight_e.html.

gaining prominence globally, spurred by recent global climate change studies, suggesting that this innovation wave will have a growing impact over the next few years.[61]

A survey in 2006 of more than 700 Institute of Electrical and Electronics Engineers (IEEE) Fellows by the Institute for the Future (IFTF) and *IEEE Spectrum*[62] revealed similar drivers. The IFTF and IEEE survey was conducted to learn what developments IEEE Fellows expected in science and technology over the course of the next 10 to 50 years. Five themes were identified as the main arteries of science and technology over the next 50 years: "Computation and Bandwidth to Burn," involving the shift of computing power and network connectivity from scarcity to utter abundance; "Sensory Transformation," the result of "things" beginning to think; "Lightweight Infrastructure," which is seen as the exact opposite of the railways, fibre-optic networks, centralized power distribution and other massively expensive and complicated projects of the 20th century; "Small World," which is described as what happens when nanotechnology starts to get real and is integrated with microelectromechanical systems (MEMS) and biosystems; and finally, "Extending Biology," resulting from a broad array of technologies, from genetic engineering to bio-informatics being applied to create new life forms and reshape existing ones.

Notably, most significant technological advances are only made possible by complementary advances in other enabling sciences and technologies. As the NRC notes, themes of "convergence" will increasingly dominate S&T development, whereby new technologies will often be a blend of two or more disciplines and advances in one field that will enable advances in another (e.g., the influence of informatics on genomics research). The convergence of nano-bio-info-cogno-technologies (sometimes referred to as NBIC technologies) is expected to produce significant advances in human health, security and industrial applications to name a few. An example of nano-bio-info technology convergence was recently announced by IBM,[63] wherein they describe the first-ever application of a breakthrough self-assembling

61 Repeated below is the NRC Renewal Futures Team report listing of important sciences and technologies that are expected to see significant advancement out to 2020:

- *Nanoscience and Nanoengineering*: The prospective impact of nanoscience and nanoengineering technologies is expected to be the most profound of all. Nanoscience—materials science on the scale of the atom and molecule—will change the very fabric of society in the long term.
- *Materials Science*: Materials science is a multidisciplinary field focusing on functional solids, whether the function served is structural, electronic, thermal, chemical, magnetic, optical or some combination of these.
- *Photonics*: Photonics refers to science and technology based on and concerned with the controlled flow of photons or light particles. As a tool, optics is making its way into virtually every field of science and technology.
- *Microfluidics*: Microfluidics is perhaps the future of the wet lab. It may be thought of as the miniaturization of the cell culture laboratory, with the ability to control complex combinations of interactions between test molecules and individual sites on individual cells.
- *Quantum Information*: Quantum information has the potential to revolutionize many areas of science and technology. It exploits fundamentally new modes of computation and communication because it is based on the physical laws of quantum mechanics instead of classical physics.

62 http://www.spectrum.ieee.org/sep06/4435.

63 http://www-03.ibm.com/press/us/en/pressrelease/21473.wss.

nanotechnology to conventional microprocessor chip manufacturing, borrowing a process from nature to build the next generation computer chips.[64]

Points of friction may slow or change the course of developments: first, is the challenge for regulators to keep pace with the rate of change in S&T development and, secondly, is a growing sense of over-reliance on S&T, which is leading to a degree of fear of technology. A dramatic example is provided in a recent Pew Internet & American Life Project poll of 742 tech experts on the question, will we be able to control our technologies in the future?[65] An unexpected 42% of survey respondents were pessimistic about humans' ability to control technology in the future, implying that the dangers and dependencies will grow beyond our ability to stay in charge of technology.

Contemplating, evaluating, understanding and responding to the inevitable rapid change that these broad drivers will generate will be an ongoing challenge for large organizations, particularly those with significant institutional inertia. And military organizations such the Canadian Forces (CF) in general, and the Army in particular, are no exception.

Significant Trend Areas

Information and Communications Technologies (ICTs)

For more than 40 years, escalating computing power has driven the growth of the information age. This has had a profound impact on information and communications technology (ICT), which comprises computers and networking devices and infrastructure, both hardwired and wireless. Mounting computing power available at decreasing prices has become synonymous with IBM's Gordon Moore and his 1965 prediction that the number of components that could be squeezed on to a silicon chip would double every year or two. The result of this remarkably consistent exponential growth trend is that a multi-core desktop computer can be purchased today for one ten-thousandth of the price but with the equivalent performance of the number one ranked supercomputer from 1991.[66] Coupled with this extraordinary price performance improvement has been an equally astonishing reduction in the physical volume and power consumption of computing devices. The result is MP3 players today that pack as much computing resources as yesteryear's mainframe computers, cell phones (essentially portable mini-computers), which have become ubiquitous the world over, and the demise of film-based cameras.

With the increase in computing power, completely new and previously unimagined capabilities are emerging in laboratories around the world. From a security perspective, computer scientists at the University of California, Berkeley, have devised a means to analyse the audio recording of keyboard clicks to determine what was being typed. Referred to as "acoustical spying," the researchers were able to take several 10-minute sound recordings of users typing at a keyboard, feed the audio into a computer, and use an algorithm to recover up to 96 percent of the characters entered.[67] Combine this capability with ubiquitous small

64 The announcement claims that chips manufactured using this technique demonstrate a 35 percent increase in electrical signal speed and can consume 15 percent less energy compared to the most advanced chips using conventional techniques.

65 http://www.pewinternet.org/PPF/r/188/report_display.asp.

66 http://www.openfabrics.org/archives/aug2005datacenter/W8.pdf (slide 7).

67 http://www.berkeley.edu/news/media/releases/2005/09/14_key.shtml.

portable digital recording devices such as MP3 players, phone cams or personal digital assistants, and the challenges to privacy and security become evident.

Although the eventual demise of Moore's law has been predicted, recent announcements suggest that innovative techniques will continue the doubling of processor power well into the early part of this century. Another massive leap in consumer computing power is expected subsequent to Intel's 45 nanometre breakthrough chips[68] hitting the market in 2007. IBM recently announced[69] that it has plans to move Moore's law into the third dimension with a new chip layering technology called "through-silicon vias," which allows different chip components to be packaged much closer together for faster, smaller and lower-power consumption systems. The announcement indicates that IBM plans to target wireless communications chips, power processors, Blue Gene supercomputer chips and high-bandwidth memory applications.[70] It can be expected that each of these areas will continue to experience exponential growth in performance over the next several decades.

On the data storage front, Caltech and UCLA researchers announced[71] the creation of a memory circuit the size of a human white blood cell, able to store 160 kilobits of data—the equivalent of 100 billion bits (100 gigabits) per square centimetre. This memory storage density, the highest ever produced, has been achieved about 13 years earlier than anticipated by Moore's Law. Disk storage is also undergoing dramatic improvement. Already, a new generation high-definition disks and players is in development, promising another fivefold increase in storage density. First-generation discs relying on red lasers could store about 5 gigabytes of data, and blue lasers have increased that to 50 GB. New systems utilizing ultraviolet lasers could raise disk densities to 250 GB.[72] Similarly, new advances are arriving in hard disk storage. While traditional spinning hard disk drive (HDD) capacities have reached the terabyte[73] range, 2007 saw the introduction of solid-state hard drives.[74] Though not competitive on a cost per gigabyte basis, solid-state drives (SSDs) offer many advantages: they are lighter, faster, quieter and less power-hungry than conventional hard drives, and they are more resistant to rough handling in portable applications and generate less heat. Recent reports have indicated that solid-state hard drives are being built with data throughput capacity of up to 62 MB/sec—about 100 times faster than conventional hard drives. This level of performance will likely lead to cell phones that can record several hours of video or, alternatively, smaller notebooks with greatly improved battery life. As with most other

68 http://www.intel.com/pressroom/archive/releases/20070416supp.htm Also included in this announcement is Intel's project Larrabee, which promises easily programmable parallel chip architectures designed to scale to trillions of floating point operations per second (Teraflops) of performance. This performance level will lead to acceleration in applications such as scientific computing, recognition, mining, synthesis, visualization, financial analytics and health applications. Intel also has specific goals to drive down power-consumption and manufacturing die-size to get to processors for ultra mobile computer usage, aiming for a 10x reduction in power-consumption in its processor portfolio by 2010.

69 http://domino.research.ibm.com/comm/pr.nsf/pages/news.20070412_3dchip.html.

70 Other than the supercomputer application, these chips are all utilized in cell phone development. If these advances deliver on the performance claims, it can be expected that cell phone performance will hit new levels. It would be reasonable to expect that cell phones will soon reach the level of performance of laptop computers.

71 http://mr.caltech.edu/media/Press_Releases/PR12942.html.

72 http://spectrum.ieee.org/mar07/4946.

73 Equal to a capacity of 1024 gigabytes.

74 http://www.sandisk.com/Oem/Default.aspx?CatID=1477.

information technologies, costs are declining as capacities rise. Indeed some reports[75] suggest that the technology is improving a little faster than Moore's Law, doubling in memory density every year.

The "computation to burn" prediction made by IEEE Fellows appears to be a highly plausible outcome from these technological developments. As computing power increases, but with lower power consumption and smaller sizes, computational abilities will be increasingly integrated into all manner of devices, turning them into smart devices and enabling the possibility of ubiquitous computing.[76]

Advances in data transmission speeds, battery life and storage capacity are changing cell phones, or smart phones, into multipurpose tools. The ability to use a phone as a television, credit card or Global Positioning System (GPS) locator is taking the device to new levels. The newest generation of phones will enable mobile web surfing able to seamlessly roam across Wi-Fi hot spots, cellular networks and new high-speed data networks. Many now expect that within ten years, the cell phone, or more realistically its evolutionary heir, will replace the laptop as the dominant internet tool.[77] Already, some cell phone manufacturers are facilitating this trend.[78]

Such trends caused the International Telecommunications Union (ITU) to identify the possibility of creating "The Internet of Things."[79] In a 2005 report, the ITU noted that the developed world is on the brink of a new ubiquitous computing and communication era, one that has the potential to radically transform our corporate, community and personal spheres. As the ICT trends continue, radio frequency identification (RFID) tags, sensors, robotics and nanotechnology will make processing power increasingly available in smaller and smaller packages so that networked computing dissolves into the fabric of things around us. Early indicators of this ubiquitous information and communications environment are already evident in the proliferation of ever more powerful and numerous cell phones.

Beyond consumer computing devices, supercomputer technology is also continuing to improve exponentially.[80] Supercomputers are used to solve complex problems, including the simulation and modeling of physical phenomena such as climate change, explosions or the behaviour of molecules, the analysis of data from sources such as national security intelligence, genome sequencing or astronomical observations or the intricate design of engineered products.[81] Their use is important for national security and defence as well as for research and development in science and engineering. The importance of supercomputer development is reflected in the US response to the Japanese Earth Simulator supercomputer that took over the top global supercomputing spot in 2002 (and held it for two years). The United States responded with significant funding and since 2004 have regained the lead with

75 http://news.com.com/Bye-bye+hard+drive,+hello+flash/2100-1006_3-6005849.html.

76 According to Xerox, ubiquitous computing is invisible, everywhere computing that does not exist on a personal device of any sort, but is in the woodwork everywhere. See http://sandbox.xerox.com/ubicomp/.

77 http://www.ipsos-na.com/news/pressrelease.cfm?id=3049.

78 http://www.technewsworld.com/story/56567.html.

79 http://www.itu.int/osg/spu/publications/internetofthings/.

80 http://www.top500.org/lists/2006/11/performance_development.

81 http://books.nap.edu/openbook.php?record_id=10784&page=1.

not one, but three, and now four, faster machines.[82] Still faster machines can be expected as next generation supercomputers relying on NEC's laser diode, called a Vertical-Cavity Surface Emitting Laser (VCSEL),[83] are developed with the potential to reach petaflop[84] performance levels.

The computing power of these machines makes it possible to conduct such high fidelity simulations that they approach real-world fidelity (and, indeed, they permit the simulation of events or phenomenon that we could not even begin to attempt in the real physical world). This, in turn, means that new innovations can be simulated on a supercomputer before any manufacturing or tooling takes place, and, coupled with rapid prototyping tools such as 3D printers, it means that new innovations can reach the market at an ever increasing rate. Barring major catastrophe, exponential technological growth will therefore almost certainly continue.

Notably, while the United States dedicates a significant portion of its supercomputer resources to military purposes, other countries (including China) are increasingly using their supercomputer facilities for commercial innovation purposes. It is unlikely to be mere coincidence that the G8 countries combined possess 417 of the world's top 500 supercomputers. It is also worth noting that China and India, which are both experiencing significant economic growth, each have more top 500 supercomputers than Canada and Russia combined.[85]

Bandwidth enabling technologies exhibit similar trends in both the cable and wireless domains. Regarding the fibre optic network infrastructure, Alcatel-Lucent Bell Labs have announced the creation of a new optical filter on a chip[86] that promises to deliver the integration of silicon electronics and fibre optics. This integration will remove bottlenecks caused by current network filters. Similarly, IBM researchers recently announced[87] a new optical transceiver chipset capable of moving data eight times faster than previous optical components.[88]

Regarding wireless networking, several technologies promise to deliver true broadband speeds that will push pervasive connectivity closer to reality. Three technologies have emerged to span short through extended distances: ultra-wideband (UWB), wireless fidelity (Wi-Fi) and World Interoperability for Microwave Access (WiMAX).

Satellite communication, an important capability for military operations, is also experiencing great change. New satellites forming part of the Skynet 5 programme recently became

82 In addition to the top four supercomputers in the world, the United States has seven in the top ten and 309 in the top 500. The United States therefore has more supercomputers in the top 500 than the combined total of the other 30 countries on the list. See http://www.top500.org/list/2006/11/100.

83 http://www.newscientist.com/article.ns?id=dn8876&print=true.

84 A petaflop is a computer processor performance measurement representing a thousand trillion floating point operations per second.

85 If supercomputing prowess is indeed an indicator of economic growth potential, then it can be expected that China and India will continue their recent growth success.

86 http://www.technewsworld.com/story/56545.html.

87 http://www.technewsworld.com/story/56545.html.

88 http://www.internet2.edu/lsr/.

operational, thus doubling the bandwidth available to UK forces in theatre within Afghanistan and Iraq.[89] This communications system is not owned by the military but rather by Paradigm Secure Communications, a consortium of defence contractors led by EADS Astrium, Europe's leading space company. Although Paradigm is under contract to the UK Ministry of Defence (under a private finance initiative) for the delivery of assured bandwidth, the arrangement allows for spare bandwidth on the new satellites to be sold to "friendly" forces, thus earning money not just for Paradigm but for the defence department as well. The CF is among those organizations that buy bandwidth from Paradigm.

The importance of all-IP-based internet routing is reflected in a recently announced[90] US Department of Defense (DoD) Joint Capability Technology Demonstration (JCTD) project to test Internet routing in space (IRIS). Intelsat General Corp., a wholly owned subsidiary of Intelsat Ltd., has been selected to demonstrate the viability of conducting military communications through an Internet router in space, which will revert to commercial use once testing has been completed. If successful, IRIS will extend the Internet into space, integrating satellite systems with the ground infrastructure, thus improving bandwidth for US warfighters, first responders and others who need seamless and instant communications.[91]

There are a variety of new radio technologies being developed, including Bluetooth, ZigBee, a growing number of cellular voice and digital services and broadcast satellite. In order for this proliferation of wireless technologies to function with minimal interference, each is restricted to specific bands of the electromagnetic spectrum. Traditional spectrum management in this fashion, however, is limited in the way it divides that spectrum into channels and in the encoding and modulation schemes it can use.[92] An emerging technology, called cognitive radio, is on the horizon, which promises to redefine spectrum management. A cognitive radio will be a wireless device that is smart enough to analyze the radio environment and decide for itself the best spectral band and protocol to reach whatever base station it needs to communicate with, at the lowest level of power consumption.[93]

Although computer hardware and networking continues to experience exponential growth, user interfaces that provide effective and efficient user access to ever growing amounts of digitized data have not been keeping pace. This will likely change within the next few years, as new modes of data manipulation are enabled though multi-touch interfaces, haptic devices and motion sensing controllers.[94] Multi-touch sensing enables a user to interact with a system with more than one finger at a time. Such sensing devices are also inherently able to accommodate multiple simultaneous users, which is especially useful for larger interaction scenarios such as interactive walls and tabletops, thus ideally suited to command and control information system displays in formation and unit headquarters. Conversely, haptic devices will enable the user to touch or feel digitized data. A haptic interface is a device which allows a user to interact with a computer by receiving tactile feedback.[95] Coupled with the

89 http://news.bbc.co.uk/2/hi/science/nature/6645987.stm.

90 http://www.intelsatgeneral.com/pdf/en/aboutus/releases/2007-4-11-IRIS.pdf.

91 Ibid.

92 http://www.spectrum.ieee.org/feb07/4892.

93 Ibid.

94 http://cs.nyu.edu/~jhan/ftirtouch/.

95 http://wii.nintendo.com/controller.jsp.

exponential advances in computer graphics quality that is increasingly delivering lifelike displays of 3-D virtual worlds, these interface devices will lead to compelling and realistic virtual environments.

Software design and development, like interface technology, is also beginning to experience significant change. Development is moving away from the sequential model, in which progress is a steady flow through the phases of requirements analysis, design, implementation, testing (validation), integration and maintenance. New methodologies will undoubtedly see greater agility,[96] enabled through information and communications technology (ICT), becoming interactive, cooperative and often real-time. Emerging development environments such as Ajax as well as presentation layer technologies will make it possible to combine data sets on demand with a minimum amount of programming. Another growing trend is the delivery of software as a web service, as epitomized by Google's Docs & Spreadsheets, which allows users to create MS Office compatible documents and spreadsheets without installing any software beyond a standard web browser. New web services, such as iUpload[97] and Knownow,[98] are also promising to provide the tools that will allow organizations to build organic, self-managed knowledge management systems, especially when coupled with enterprise search and business intelligence applications.

Combined, innovations in computer processing, memory capacity, disk storage, bandwidth, interfaces and software development will continue to drive ICT innovation. The importance of ICT for national development and economic growth must not be underestimated. The World Economic Forum's benchmark Global Information Technology Report, which assesses national ICT strengths and weaknesses, highlights the continuing importance of ICT.[99] The strong correlation between those nations with poor performance on the World Economic Forum's Network Readiness Index[100] and the Failed States Index[101] provided by Foreign Policy.com reinforces the importance of global ICT for not only economic development but also global security. Similarly, in its Information Economy Report 2006, the United Nations Conference on Trade and Development (UNCTAD) indicates that global economic processes, including international trade, are increasingly influenced by the creation, dissemination, accumulation and application of information and knowledge.[102] It concludes that development can no longer be understood without full consideration of the widespread effects of ICT. The report estimates that broadband networking could contribute hundreds of billions of dollars a year to the GDP of developed countries in the next few years. Broadband networking is compared in importance to utilities such as water and electricity. The UNCTAD warns that the growing importance of high-speed internet access is "disturbing news" for the developing world, where broadband access is scarce, because technology is exerting an ever greater influence on global business trends.[103]

96 http://www.agilealliance.org/.

97 http://www.iupload.com/.

98 http://www.knownow.com/.

99 http://www.weforum.org/en/initiatives/gcp/Global Information Technology Report.

100 http://www.weforum.org/pdf/gitr/rankings2007.pdf.

101 http://www.foreignpolicy.com/story/cms.php?story_id=3420&page=1.

102 http://www.unctad.org/Templates/WebFlyer.asp?intItemID=3991&lang=1.

103 http://www.itu.int/ITU-D/ict/statistics/.

The global proliferation of information and communications technologies is enabling revolutionary capabilities. Supercomputing is no longer the sole purview of wealthy nations. Broadband networks, coupled with the proliferation of increasingly powerful and internet connected personal computers, has delivered supercomputing to the masses. Large technology players such as IBM, Sun Microsystems Inc. and Hewlett-Packard Co. already sell computing power, on a grand scale, to large corporations. New services, however, from Amazon.com Inc. and 3tera Inc., for example, are bringing on-demand computing to midsize and small businesses. This concept is known as hosted hardware or grid computing and relies on a technique called virtualization.[104] Remarkable levels of processing power have been harnessed using this technique. The Berkeley Open Infrastructure for Network Computing (BOINC) application, for example, links nearly 2 million computers into 41 different research projects. Since the BOINC application is open source, it is reasonable to predict that there will be more projects added over time. It may be difficult, however, to ensure that new projects are not designed for malicious purposes but disguised as benevolent research.

Yet another ICT-enabled trend is the proliferation of internet hosted storage. Recently, Yahoo! announced that it would offer unlimited email storage space for its users.[105] Google's Gmail on the other hand, provides its users with nearly 3 gigabytes of file storage. Each of these offerings would undoubtedly not have been possible without the cost performance increases in data storage noted earlier.

Microchips are becoming more energy efficient, smaller and ever more powerful. Computational competence, and network bandwidth, whether it is by fibre-optic cable or wireless, is continuing to proliferate and grow in importance as a vital national capability.

The importance of information technologies and networking has been acknowledged within military environments for many years. Indeed, the success of the adaptive dispersed operations concept for the Army of Tomorrow hinges on adequate distribution of information and communications technology to the lowest levels, including individual dismounted soldiers. The premise here follows the logic that networking everyone and everything will empower the edges of the network[106] to make independent decisions. The parallels to mission command philosophy within current Army doctrine should be evident. Ubiquitous networking also fits well with James Surowiecki's "Wisdom of Crowds" thesis,[107] i.e., that large groups of people are smarter than an elite few, no matter how brilliant the latter may be. Networked crowds are better at solving problems, fostering innovation, coming to wise decisions and even predicting the future. Many questions remain unanswered, though, particularly with respect to the impact that this will have on human resource decisions. For example, what will be the most important selection criteria for leaders in the future? What will be the measure of a good commander in this era? Should it be previous operational experience or human

104 http://folding.stanford.edu/.

105 http://yodel.yahoo.com/2007/03/27/yahoo-mail-goes-to-infinity-and-beyond.

106 www.dodccrp.org/publications/pdf/Alberts_Power.pdf.

107 This idea of tapping into the collective intelligence of opinion of a broad audience is now often referred to as "crowdsourcing," a play on the term outsourcing. A typical application for crowdsourcing, is citizen journalism, in which the public participates in the reporting process. New applications such as CrowdSpirit (http://www.crowdspirit.org/how-it-works) are arriving on a regular basis. Many large vendors, such as Dell Computers with their Idea Storm site (http://www.ideastorm.com/) are also tapping into this phenomenon.

resource management skills? Trends visible within commercial sectors may provide insight: the most successful CEO's today are those who nurture, develop and create an environment that empowers the edges, embracing and encouraging the innovative potential of the "crowd." While mission command may be a step in this direction, it may be but a small step compared to the potential for empowering everyone and everything on the battlefield.

One of the key benefits of the information and communications technology environment is the manner in which it has enabled people to network. A key by-product of this situation has been a dramatic increase in collaboration, often on a global scale. An area that has benefited greatly from this "wisdom of crowds" type of collaboration has been the open source software movement. The open source initiative[108] has produced robust applications that today have become a globally significant challenge to conventional proprietary software. The sheer scale of global network collaboration has led to the development of open software in practically every application domain, producing software and source code that is free to download, use and modify.

Proponents of the open source software philosophy claim that the fact that open source code is transparent and freely available helps to make open source more secure than commercial software. Conversely, others suggest that the lack of contractual agreements between vendor and purchaser in the open source world makes open source deployments less secure. While it is unlikely that this debate will be settled any time soon, it is very likely that open source software adoption will flourish in developing nations due to the prohibitive cost barriers presented by the commercial software alternatives. Given the high quality of many open source offerings, combined with numerous global users who contribute patches, fixes and upgrades, there is very little disadvantage to developing nations following this approach. The costs of sharing code are low, while the benefits are high. The One Laptop Per Child (OLPC) project,[109] which utilizes exclusively open applications, will only serve to strengthen the open source movement within developing nations. It is possible that the Open Source Initiative coupled with the OLPC, could be the impetus behind Microsoft's recent announcement to slash software prices for students in developing nations.[110] Microsoft plans to offer a limited version of its Office software suite to schoolchildren in developing countries for the price of three dollars per copy. When combined with open source offerings, there is a potential to narrow the existing digital divide.[111] It is clear that open source software is a growing trend that empowers individuals with advanced information and communications technology tools and capabilities, regardless of their location or financial means.

The open source movement is also dramatically changing the face of education. The Massachusetts Institute of Technology (MIT), for example, initiated its groundbreaking OpenCourseWare (OCW) program six years ago.[112] OCW is a free and open educational resource (OER) for educators, students and self-learners around the world. The OCW currently provides open access to course materials for up to 1,550 MIT courses, representing

108 http://www.opensource.org/.

109 http://www.laptop.org/en/vision/index.shtml.

110 http://www.microsoft.com/middleeast/press/presspage.aspx?id=200718.

111 http://www.developmentgateway.org/?goo=147.

112 http://web.mit.edu/newsoffice/2001/ocw.html.

34 departments and all five MIT schools.[113] The goal is to include materials from all MIT courses by 2008. Since MIT's efforts, eleven other US colleges have indicated plans to offer similar OCW, and five already have an online presence.[114]

Another rapidly evolving trend is the social networking phenomenon, including wiki's, blogs, social bookmarking and tagging. Each of these areas shares similarities with the open software initiative noted above. Their strength lies in maximum participation and collaboration of the user community.

Artificial Intelligence

Artificial intelligence research has experienced a resurgence in activity due to the progress made in ICT and other fundamental scientific research areas. Some experts believe the arrival of autonomous technological intelligence to be inevitable (extremely probable as a physical event) but propose that the manner and timing of the transition remain key choices under the influence of human beings.[115] Notable about current artificial intelligence (AI) predictions, however, is the fact that experts are once again daring to make predictions about the future of AI. Failure to deliver on the AI hype of the late 80's and early 90's led to the evaporation of AI research funds. It now appears that a critical mass of research aimed at creating true artificial intelligence (and other advanced technologies, including robotics) is rapidly converging.

Already, there are numerous examples of niche areas where machine intelligence surpasses human level abilities. Wallace Forbes, President, Forbes Investors Advisory Institute, claims that their proprietary computer software program, the "Quant Model", is outperforming most human portfolio managers at stock picking. Forbes claims that more than 75% of portfolio managers under-perform the market, whereas over a ten-year period, the Quant Model outperformed the S&P 500 by a staggering 362%.[116] There are a growing number of these niche domains where AI performs as well as, or better, than humans. These narrow areas could eventually converge, yielding increasingly capable AI systems that cover broad domains.

One successful area of AI implementation concerns intelligent agents. An agent is a program (typically web based) that runs automatically without a user needing to start it once it has been configured. For example, the online job service Monster Board (www.monster.com) allows users to enter the types of jobs they are looking for. Even when users are offline, the agent scans the Monster Board job database daily and sends an e-mail when it finds a job matching the user's criteria. The ongoing development and improvement of the semantic web[117] promises to establish a data and knowledge framework that will allow more sophisticated information and knowledge automation through intelligent agents.

113 http://ocw.mit.edu/OcwWeb/Global/all-courses.htm.

114 http://oedb.org/library/features/how-the-open-source-movement-has-changed-education-10-success-stories.

115 http://www.accelerationwatch.com/singtimingpredictions.html.

116 http://www.forbesinc.com/newsletters/fgi/.

117 The semantic web is an extension of the current web in which information is given well-defined and structured meaning, better enabling computers and people to work in cooperation. See http://www.w3.org/RDF/Metalog/docs/sw-easy.html.

Announcements of progress in various AI-related fields appear on a regular basis.[118] Many of the greatest strides in AI research have been achieved by implementing algorithms that learn through observation and mimicry. Some researchers are now anticipating that the web will be the source of the raw knowledge necessary to seed future AI with the common-sense knowledge necessary to give them human levels of intelligence.[119]

Though there is a growing consensus that human-level machine intelligence will be achieved, there is wildly varying opinion as to its timing. Some speculate that this could occur as early as 2029.[120] It is likely that AI development will follow the same trends as practically all other technologies: it will progress in incremental steps, each one building on previous successes. This "accelerating returns" development methodology suggests that there will not be a catastrophic over-night development that catches humanity unaware. Rather, it will take place via a series of deliberate choices made along the way, with each incremental serving to address some immediate human need. Code breaking, aircraft auto-pilot systems, unmanned aircraft or cruise missiles are just some of the examples of this.[121]

As AI systems achieve greater levels of ability, they will increasingly replace functions that were once the sole purview of humans. Machines are already exceeding humans in the performance of more and more tasks, for example, managing the power grid[122] or guiding objects like missiles or satellites and assembling other machines.[123] It will be important for Army capability development efforts to remain aware, indeed, to ride the wave of AI developments as they continue to accelerate along with the other exponential growth areas.

At some point, military related AI will reach a threshold of ability that threatens to cross moral, ethical and/or legal boundaries, e.g., an autonomous system that is able to make life-and-death decisions within chaotic or dynamic environments. While the current approach is to ensure the presence of a human in the decision-making loop, this may not be as suitable in future. It is possible that there will be situations wherein events transpire so rapidly that typical human response times would be wholly inadequate. The beginning of this trend is already apparent. Automated countermeasures such as active armour must deploy in milliseconds, well before human operators would be able to sense and respond to an incoming threat.

Given recent progress in AI and the likelihood that it will reach a point of sophistication that challenges human abilities in broad areas, it is prudent for those within capability development organizations to be mindful of the moral, ethical and legal ramifications of AI-related development decisions. The fact that automation is currently seen as a force multiplier only underlines this need. These issues must be debated in order to determine what the moral and ethical boundaries for AI systems should be. That said, moral and ethical boundaries may shift as societies change and adapt to new technologies.

118 http://www.newscientist.com/article.ns?id=dn6914.

119 http://www.newscientist.com/article.ns?id=dn6924.

120 http://www.kurzweilai.net/meme/frame.html?main=/articles/art0655.html.

121 http://www.darpa.mil/grandchallenge/index.asp.

122 http://www.scientificcomputing.com.

123 http://www.kurzweilai.net/meme/frame.html?main=/articles/art0637.html.

Cybernetic Systems

Cybernetic systems technology is another area that is rapidly developing due to the exponential growth of many of the enabling technologies. Cybernetics pertains to the integration of mechanics, electronics, bionics and robotics. A prime example of a cybernetic system is an exoskeleton.[124] A more dramatic example is the bionic arm developed at the Rehabilitation Institute of Chicago, within the Neural Engineering Center for Artificial Limbs (NECAL). The arm utilizes a pioneering muscle reinnervation procedure, which takes an amputee's own nerves and connects them to a healthy muscle.[125] This technique allows a user to move a prosthetic arm as if it were a real limb, by simply thinking about what they want the arm to do. The "bionic," or myoelectric, arm is driven using electrical signals from the muscles of the chest, now activated by the user's own thought-generated nerve impulses. These impulses are sensed, via surface electrodes, from the pectoral muscle and carried through to the mechanical arm, causing the arm to move. Aside from the obvious benefits for the disabled community, this rapidly evolving technology holds potential for the development of new capabilities such as tele-presence.[126]

Robotics

Robotics is another area that is experiencing exponential growth. Researchers believe that robotics is on the verge of becoming the next major commodity technology, perhaps surpassing the computer in importance.[127] The US DoD appears to think so as well: despite the obstacles, the US Congress ordered in 2000 that a third of the ground vehicles and a third of deep-strike aircraft in the military must become robotic within a decade. The United States has already spent many billions of dollars on military robotics attempting to meet this mandate. Technological breakthroughs have been achieved, though the detailed results of this program are not public knowledge.

A 2006 Australian Defence Science and Technology Organization (DSTO) study[128] that examined issues of situational awareness generation within autonomous systems concluded that in strategic terms, robotics has passed the point of being a new strategic threat to one that broadens the threat at the operational and tactical level. The key feature is commoditization, enabling different actors to utilize formerly specialized technology. The threat space from autonomous systems thus builds on advances and commoditization of enabling

124 http://www.newscientist.com/article.ns?id=mg18624945.800.

125 http://www.ric.org/bionic/.

126 For example, imagine being able to control the functions of a humanoid robot simply by thinking about it. Then combine an intelligent humanoid robot with a network based interface, and it is feasible that an operator will be able to think about what the tele-robot should do, with its own intelligence functions compensating whenever there was a network lag or interruption. Then imagine the feedback from the robot returning directly to your brain, providing tactile sensation (see http://www.sony.net/SonyInfo/QRIO/top_nf.html) as well as visual and auditory information. These trends suggest that it may soon be possible to "be there" without ever leaving home. Potentially, if the sensory feedback information achieves a sufficiently high resolution, in your mind, you would actually be there. While this level of capability is unlikely to be achieved within the timeframe covered by this paper, this type of cybernetic system is likely to become a factor in the future.

127 http://www.sciam.com.

128 Patrick Chisan Hew, *The Generation of Situational Awareness within Autonomous Systems—Near to Mid Term Study—Issues*, Australian DoD, Defence Science and Technology Organization, DSTO-GD-0467, Edinburgh, South Australia 5111 Australia, July 2006. See http://dspace.dsto.defence.gov.au/dspace/handle/1947/4560.

technologies, including insertion into civilian communication networks and computer hardware and software.[129]

The advances in enabling technologies point towards increasing levels of machine awareness and autonomy, which will require careful consideration by capability developers as to acceptable modes of operation given societal expectations and constraints.

While there has been a surge recently in humanoid robotics,[130] e.g., "smart" munitions, it is likely that robots will continue to take a variety of shapes and forms. Indeed the first commercially available home service robots,[131] or tactical robots,[132] from iRobot do not resemble our historical science fiction depiction. Many future robots will likely be an assembly of components that reconfigure themselves to suit the task at hand.[133]

Reconfigurable robots have emerged from the field of swarm robotics—the notion that a collection of many small and cheap robotic units can act as an autonomous entity. Ant colonies have provided biological inspiration in that they exhibit a kind of swarm intelligence that enables the ants to forage far more effectively as a collective than if they were each to act independently. Importantly, there is no central control centre directing the activity. Instead, the collective behaviour emerges spontaneously, which can make it adaptive and efficient without the need for sophisticated decision-making software. An extension of this idea involves reducing the size of the components so that they become autonomous "atoms" that can build structures with a wide range of functions and properties. Such miniaturized swarm robots have been dubbed "smart dust"[134] and are encompassed in the emerging concept of "claytronics."[135] Swarm robotics might provide a better way of monitoring remote environments on earth and on other planets. Not only can robot swarms search more efficiently, but they also are potentially more robust against failures.[136]

Other biologically-inspired robots include mechanical insects, which some researchers suggest could prove far more manoeuvrable than micro-sized versions of conventional aircraft or helicopters.[137] Such insect-like craft could fly unobtrusively around buildings, moving into open windows. When equipped with different sensor types, they could be used as miniature hazard monitors. The US Defense Advanced Research Projects Agency

129 The DSTO report decomposes the concept of *autonomous situation* awareness into three continuums:

- *Autonomy*, measured by the time between references to a human being for input.
- *Awareness*, measured by the system's usage of information about its environment. Importantly, the system will only use a subset of the total information available.
- *Situation*, driven primarily by the severity of consequences of the system making decisions and taking action. Severity of consequences is the critical link to the human decision to employ the autonomous system

130 http://www.nasa.gov/vision/universe/roboticexplorers/robots_human_coop.html.

131 http://www.irobot.com/sp.cfm?pageid=95.

132 http://www.irobot.com/sp.cfm?pageid=109.

133 http://www.sigmascan.org//ViewIssue.aspx?IssueId=302.

134 http://www-bsac.eecs.berkeley.edu/archive/users/warneke-brett/SmartDust/index.html.

135 http://www.cs.cmu.edu/~claytronics/.

136 http://www.sigmascan.org//ViewIssue.aspx?IssueId=302.

137 http://www.newscientisttech.com.

(DARPA) is developing four flying "robobugs," weighing up to 10 grams each, with wingspans of up to 7.5 centimetres. Aerovironment, one of the companies developing the craft for DARPA, aims to have a rough demonstrator flying by the middle of 2008.[138] These robotic insects are expected to become cheap and commonplace due to their size and weight (less than a tenth of a gram) and could sell for less than a dollar.

Yet another class of robots is being studied. It uses a network of cultured animal neurons to control its functions.[139] Researchers have shown that the cultured "brain" grows more complex as it learns and interacts with the outside world through the robot's actions. Combined with new forms of robot power, such as artificial muscles[140] made from electro- or chemically-active polymers, it can be expected that there will be significant progress in robot mobility, control and self awareness. Already a star-shaped robot exists that is able to sense and respond to changes in the environment and damage to its own body by continuously refining its built-in software.[141]

Overall, robotic technologies are maturing at an accelerating pace. New, commercially available unmanned aerial vehicles (UAVs) are reaching the market with increasing frequency and with impressive performance specifications: achieving about 50% of the speed, range and endurance of much more expensive military UAVs.[142] More significantly, some models can be purchased in a fully autonomous version for under $25k. With a quiet electric drive and onboard video, it is now feasible for belligerents to use such a system for covert surveillance and target detection inside coalition camps. As a more sinister prospect, it could be used as a cheap cruise missile, perhaps to deliver biological agents. As these cheap but capable systems proliferate, current concepts that rely upon information superiority may become increasingly problematic. In fact, without remaining near the leading edge of commercial technology, information inferiority is possible. Criminal and terrorist groups continue to generate billions of dollars through internet crime, thereby making it feasible that they will be able to buy state-of-the-art commercial technology whenever they wish, with delivery the next day through UPS. Currently, the same cannot be said for the CF procurement system.

Compounding the problem of commercially available robotics is the hacking of their capabilities.[143] A growing list of internet sites now offer hacking ideas as well as software code.[144] A Roomba vacuum costs a few hundred dollars and contains sophisticated electronics, making it a candidate for use as a fully autonomous IED able to identify and attack intended targets without human over watch. While our troops today are facing fairly low tech enemies, this may well change. Already, trends in Iraq and Afghanistan reveal the ability of adversaries to integrate various commercial technologies into increasingly sophisticated improvised explosive devices. Indeed, the 9/11 attack on the United States

138 Ibid.

139 http://www.gatech.edu/news-room/release.php?id=125.

140 http://sbir.nasa.gov/SBIR/successes/ss/9-066text.html.

141 http://www.news.cornell.edu/stories/Nov06/ResilientRobot.ws.html.

142 http://www.rctoys.com/rc-toys-and-parts/DF-TANGORC/INDUSTRIAL.html.

143 http://todbot.com/blog/category/roomba/.

144 http://www.botmag.com/.

was a crafted combination of low tech (box cutters) and high tech (Boeing 767 aircraft). In short, the use of autonomous systems by adversaries will likely increase.

By 2025, robots could look, act, think and feel like humans.[145] Although many technical problems still exist, they are being overcome. The ability of humans to engage robots emotionally is prompting researchers to reflect on the human-robot interaction, questioning whether the relationship should evolve from a simple human-tool perspective to a more complex team-mate relationship. Other researchers caution that it is unlikely that machines will have the ability to engender an emotional level of trust—a prerequisite for a team.[146] Still other researchers believe that by 2015 robotic vehicles will be employed on the battlefield for convoy operations or in areas where there is extreme danger to personnel.

Design methodologies capable of facilitating this transition to robotic vehicles are already well established in the commercial automotive industry. There are more and more electronic and electromechanical components and systems in vehicles today, from simple solenoids and motors to embedded microprocessors that control braking, steering and engine operations.[147] Combined with a well-developed network of sensors and electronically controlled actuators for practically every vehicle system, it is reasonable to anticipate the emergence of commercial robotic vehicles. Micro-electromechanical systems (MEMS) miniaturized, self-contained systems (on the order of the width of a human hair, or micron scale) that integrate electrical and mechanical functionality to sense, process and act upon information in their environment will further advance automotive and robotic technologies. MEMS are batch fabricated using techniques similar to those used in the integrated circuit industry. The autonomous, miniaturized nature of MEMS decreases the cost and increases the functionality of the products into which they are integrated. MEMS will have a significant effect on the development of “intelligent” products in a wide range of industries, including aerospace, healthcare, automotive and consumer goods. This integration of electronics, mechanics, software and controls within the automotive industry is called mechatronics—a process which will clearly drive further advancement of robotics technologies.

Robots, including unmanned ground vehicles (UGVs), have many valuable attributes that will aid and complement soldiers on the battlefield. They are well suited to perform routine and boring tasks. They are fearless and tireless. They do repetitive tasks with speed and precision. They can be designed to avoid or withstand enemy armaments and to perform specific military functions. And most importantly, robots can reduce casualties by increasing the combat effectiveness of soldiers on the battlefield.[148]

Early autonomous UGV and UAV implementations will likely target mapping tasks within urban settings. Engineers have developed a technique called “virtualized reality” that could be used to map unknown city areas, building accurate, three-dimensional maps street by

145 http://www.newscientisttech.com/article/mg19325966.500?DCMP=NLC-nletter&nsref=mg19325966.500.

146 Ibid.

147 http://www.designnews.com/article/CA6424936.html?nid=3198&rid=2052535400.

148 Technology Development for Army Unmanned Ground Vehicles, Committee on Army Unmanned Ground Vehicle Technology, Board on Army Science and Technology, Division on Engineering and Physical Sciences, NATIONAL RESEARCH COUNCIL OF THE NATIONAL ACADEMIES, THE NATIONAL ACADEMIES PRESS, Washington, D.C. Copyright 2002 by the National Academies Press. See http://books.nap.edu/openbook.php?record_id=10592&page=13.

street, recording every window and doorway of the urban battlefield.[149] This automated technique employs lasers to measure distances to objects and building facades, while a digital camera takes 2D photos. Following data processing, the system creates a photo-realistic virtual 3D model of the area that could be used for training and mission rehearsal.

Virtual Reality and 3D Modelling

Significant progress is also being made in the area of 3D modelling and virtual reality. These technologies have the potential to radically alter military training techniques. Some believe that by 2020 real and virtual environments will become practically indistinguishable. Already, digital clones of people have been created using 3D scanners and high resolution cameras capable of capturing skin pores and wrinkles. In less than a minute, a system of scanners and cameras can capture enough data to create a 3D digital double that can be aged, given a sun tan or realistically illuminated to fit into almost any situation.[150] Combining these realistic 3D virtual models and characters with sophisticated AI algorithms within first-person video environments will offer compelling training environments. Adding haptic resistance feedback interfaces will further enhance the experience by introducing a means to induce fatigue. Current video gaming environments already combine many of these techniques to create convincing situations. Moreover, they endow fellow digital soldiers with the ability to follow and sometimes lead, providing covering fire and warning about snipers and grenades.[151]

Trends within the commercial sector will further enhance the development of virtual reality environments. Numerous companies (e.g., Dell, IBM, Toyota, Sony BMG) have purchased digital territory within one of today's leading online virtual environments, Second Life.[152] Since its introduction in 2003, the number of virtual avatars within this virtual world continues to grow exponentially. Recently, IBM recommended more integration between the various online virtual worlds where avatars meet.[153] IBM will be attempting to make it possible for a user in one virtual world to take the assets created in that environment and move them to other worlds, which IBM executives have described as a "virtual planet." The Metaverse Roadmap (MVR) project[154] describes the metaverse as the result of the convergence and merger of existing evolving technologies: when video games meet Web 2.0, when virtual worlds meet geospatial maps of the planet, when simulations get real and life and business go virtual, when you use a virtual Earth to navigate the physical Earth, and when your avatar becomes your online agent.

At the opposite end of the same technological spectrum lies "embodied virtuality," which has been described as the process of drawing computers out of their electronic shells, miniaturizing them, and placing them in everything—cars, buildings, appliances and human bodies. The likely outcome of this pervasive computing environment is the ability to create augmented

149 http://www.newscientist.com/article.ns?id=mg18624985.800.

150 http://www.newscientisttech.com/article/mg19426006.800.

151 http://www.technologyreview.com/InfoTech/wtr_16479,294,p1.html.

152 http://www.smh.com.au/articles/2007/04/23/1177180526985.html.

153 http://www.cio.com/article/107551?source=nlt_cioinsider.

154 MVR is the first public ten-year forecast and visioning survey of 3D Web technologies, applications, markets and potential social impacts. See http://metaverseroadmap.org/.

reality. These emerging technologies make it possible to deliver immersive education and training to anyone, regardless of time or location. Already, augmented reality gamers are turning the real world into virtual battle zones using existing technologies such as GPS and web enabled cell phones.[155] These examples reveal the powerful potential of a fully network-enabled force, i.e., one that has communications, computation and location-based services.

Early commercial implementation of ubiquitous computing is already underway in South Korea's Songdo City, which is projected to be an international commercial centre and the first true U-city ("U" being the shorthand for ubiquitous computing).[156] The city's infrastructure will allow all IT systems—whether belonging to government agencies, corporations, healthcare providers, or private citizens—to share data. Every street, every house, every office will be wirelessly networked, demonstrating the benefits (or pitfalls) of living a digital lifestyle. And an array of new RFID-based services will underpin the system.

Biotechnology

Many of the same growth trends are evident in the realm of biology. Indeed, ICT has revolutionized the study of biology, making it in essence an information technology subject to the similar exponential growth and accelerating return. According to Ray Kurzweil, bio-related technologies continue to double their price performance and capacity every year.[157] Kurzweil projects that biotechnologies will experience an increase in capability by a factor of one thousand within a decade and by a factor of one billion by 2030.

The magnitude of biotechnology development has profound implications, holding the potential to fundamentally alter life on earth. Signs of the power and potential of biotechnologies are evident in steps taken towards developing a malaria-resistant mosquito, a measure that could potentially reduce the spread of malaria.[158] Bio-related developments will likely continue to face some resistance due to the real or perceived consequences to ecological and human health made possible by genetic modification of organisms.[159]

Despite early resistance, some researchers foresee a rapidly approaching era where biology hacking becomes commonplace, thus potentially amplifying the threat of bio hazard situations. The exponential pace of technological development in biotechnology and genetics adds plausibility to this assertion. New generations of sophisticated tools are being developed continuously,[160] resulting in research labs upgrading their equipment and selling their "old" hardware at discount rates. This discount equipment is more than adequate for conducting research and thereby enabling a proliferation of bio-related threats.

155 http://www.newscientist.com/article.ns?id=mg18625036.200.

156 http://www.songdo.com/default.aspx.

157 http://www.sciam.com/print_version.cfm?.

158 http://www.jhsph.edu/publichealthnews/articles/2007/jacobs_lorena_mosquito.html.

159 http://www.ornl.gov/sci/techresources/Human_Genome/elsi/gmfood.shtml.

160 New lab tools, such as microfluidic lab-on-a-chip technology, are maturing rapidly and promise to further accelerate existing biology fields and spawn entirely new subjects of study. For example, the study of biology is now subdivided into such areas as genomics (the study of genes and their functions) and proteomics (the study of proteins that genes encode).

Open access databases and knowledge warehouses add to the potential risk. Whether scientific information should be published for the public good or safeguarded due to its threat potential remains a matter of debate. Within the last 30 years, the genomes of thousands of organisms, from viruses to bacteria to humans, have been sequenced or partially sequenced and deposited in databases freely accessible to scientists around the world. This information is accelerating scientists' ability to fight disease and make other medical advances, but policymakers must also consider the possibility that the information could be used for destructive purposes such as in bioterrorism or war.

Current policies allow scientists and the public unrestricted access to genome data on microbial pathogens. The US National Research Council Committee on Genomics Databases for Bioterrorism Threat Agents concluded in their report that open access improves our ability to fight both bioterrorism and naturally occurring infectious diseases. Security against bioterrorism is better served by policies that facilitate, not limit, the free flow of this information.[161] The report also notes that the database of available information is significant, comprising the entire genomes of many hundreds of organisms, from viruses to bacteria to humans, and partial sequences from many thousands more organisms. Complete genomes of more than 100 microbial pathogens—including those for smallpox, anthrax, Ebola hemorrhagic fever, botulism and plague—are already in Internet-accessible databases freely open to all, and the genomes of hundreds more pathogens will be sequenced with the support of government funds in the next few years.

Given these risks, the need exists for continuous and thorough evaluation of scientific technology as it affects national security and health and welfare.[162] Despite the dual-use dilemma of bioterrorism, modern biological research is a thriving international enterprise with enormous potential to benefit society. The synergy created by increasing knowledge and open exchange of ideas and information is accelerating the advance of medicine, industry and agriculture. Emerging details about the interplay between pathogenic micro-organisms and their hosts will allow scientists to continue to develop and deliver new and improved vaccines, stronger infection-fighting drugs and more-precise diagnostic tools.[163]

The potential of biological research was discussed at the Accelerating Change Conference held at Stanford University in 2005. Several respected members of the scientific community outlined the impact that bio-related technologies and research were having on our understanding of life and death. Some researchers are beginning to view aging as a disease that could one day be curable. Even if this is a bridge too far, an inevitable result of the rapid pace of biotechnology development will be increased human life-spans. This trend is already evident. According to the Municipal Research and Services Center in Washington, the United States is on the brink of a longevity revolution.[164] By 2030, the number of older Americans will have more than doubled to 70 million, or one in every five Americans. The growing number and proportion of older adults places increasing demands on the public health system and on medical and social services. Canada will face similar pressures that will

161 http://www.nap.edu/catalog.php?record_id=11087#description.

162 The CBRNE Research and Technology Initiative lead by DRDC is an excellent example of the proactive approach being taken by Canada. See http://www.crti.drdc-rddc.gc.ca/en/default.asp.

163 Ibid.

164 http://www.mrsc.org/Subjects/Governance/DemogOver.aspx.

change society in ways that are still uncertain. There is potential for human resource shortages. Indeed, there may be a reduction in the pool of available recruits for the future armed forces. Japan, has already recognized this aging trend and has begun huge investments in robotic technology to offset some of its impacts (e.g., a smaller labour force).[165]

The bio-tech revolution holds equally important implications for the human dimension. Since the unlocking of the human genome, the scientific community's ability to tinker with the code of life has expanded enormously, leading to discoveries that, only a few short years ago, were impossible. For example, progress is being made towards understanding and, more significantly, manipulating the genetic basis of the fear response. While it is not unreasonable to think that such genetic manipulation can only be undertaken within a laboratory environment, recent advances point to the potential for manipulating the manner in which genes are expressed by modifying the food we eat.[166] Notwithstanding the moral, ethical and legal resistance that could attend such possibilities, there is growing evidence that points to the potential for radical human enhancement. The developing areas of nutrigenomics[167] and personalized nutrition, for example, promise to offer products that are tailored to suit disease prevention based on one's individual genetic make-up.[168]

These capabilities have both offensive and defensive implications both for the Army of Tomorrow and the Army of the Future and raise a myriad of questions. For example, will the CF harness this capability to make its soldiers truly fearless warriors in the face of the enemy? Could this ultimately mitigate the effects of post traumatic stress? While this may remain (problematic) too radical for western democracies, it may not be so for a well-funded terrorist cell or crime network. Perhaps by eliminating their fear, terrorist groups could "recruit" an infinite number of future suicide bombers.

The science-fiction-like abilities being developed though genetic engineering are likely to become ever-more disruptive in coming decades. Force development activities must heed such developments and potential scenarios that include such radical capabilities if we are to be prepared for future defence and security threats.

Complicating the situation is the evolving research area of synthetic biology. Synthetic biology is described as the design and construction of new biological parts, devices and systems, and the re-design of existing, natural biological systems for useful purposes.

In much the same ways that electrical engineers rely on standard capacitors and resistors, or computer programmers rely on modular blocks of software code, synthetic biologists are attempting to develop an array of modular biological parts that can be readily synthesized and mixed together in different combinations. Already, the Massachusetts Institute of Technology (MIT) has a Registry of Standard Biological Parts, or BioBricks, that supports this goal by indexing biological parts that have been built and offering assembly services to

165 http://www.globalaging.org/health/world/2005/robot.htm.

166 http://www.newscientist.com/channel/health/mg18825264.800.html.

167 Nutrigenomics is the science of how food and ingested nutrients affect genes, particularly those related to disease prevention.

168 http://www.newscientist.com/channel/health/mg18825264.800.html.

construct new parts, devices and systems.[169] In essence, synthetic biology is an attempt to construct life starting at the genetic level. Remarkable and occasionally alarming results have been achieved. A live polio virus was created from scratch using mail-order segments of DNA and a viral genome map that is freely available on the Internet.[170] Experts worry that synthetic biology may spawn bio-hackers. One expert in the field, Harvard University genetics professor George Church, compared the potential misuse of synthetic biological designs with that posed by nuclear weapons. But, in his view, there is one important difference: it is much harder to build a fusion device than to genetically engineer a pathogen. And the complexity of biological processes also increases the danger of accidents.[171]

This domain of research will undoubtedly see dramatic increases in capability as vendors such as Microsoft Research (MSR) continue to offer grants targeting research projects in this field.[172] According to an article in PLoS Biology, the peer-reviewed, open-access journal published by the Public Library of Science, synthetic biologists aim to make biology a true engineering discipline rather than simply transferring a pre-existing gene from one species to another.[173]

If insurgent groups succeed in harnessing the full disruptive potential of synthetic biology, our present capability development efforts, which in large measure rely upon kinetic energy weapons, may become irrelevant. As this technology matures, there will likely be a need to reassess the balance of investment amongst the operational functions, with Sense and Shield capabilities rising in importance. Perhaps the sensor-to-shooter link of the future, instead of delivering a kinetic energy round, will need to deliver a synthetic biological entity antidote.

Growing understanding of brain function is also leading to less invasive, but nonetheless dramatic, improvements in human performance potential. For example, the US DARPA is seeking to combine several technologies into a system that literally taps the wearer's prefrontal cortex to warn of furtive threats detected by the soldier's subconscious.[174] This system will integrate technologies that have been available in laboratories for years, ranging from flat-field, wide-angle optics to the use of advanced electroencephalograms, or EEGs, to rapidly recognize brainwave signatures. Commercial developments promise to expand this capability well beyond the defence sector. For example, San Jose, California-based NeuroSky[175] recently announced the development of a cost effective biosensor and signal processing system for the consumer market.

Nanotechnology

Researchers suggest that the first physical-neural interface between a computer and a human brain (probably serving a prosthetic function) may be demonstrated within the 2015

169 http://parts.mit.edu/registry/index.php/Main_Page.

170 http://www.nature.com/doifinder/10.1038/431624a.

171 http://www.eetimes.com/news/latest/showArticle.jhtml.

172 http://research.microsoft.com/ur/us/fundingopps/RFPs/eScience_RFP_2006.aspx.

173 http://biology.plosjournals.org/perlserv/?request=get-document.

174 http://www.darpa.mil/sto/solicitations/SN07-20/inex.html.

175 http://www.neurosky.com/.

to 2020 timeframe.[176] Such neural interfaces will provide a direct connection between a human or animal brain and nervous system and a computer or computer network. With the advent of such interfaces, humans will be able to interact directly with computers by merely thinking. Admittedly, successful implementation of a neural interface may come from researchers working on human perception and prosthetic engineering at the intersections of medical and computer science, neural signalling, electronics and signal processing. Increasingly, however, progress in the domains of molecular biology, nanotechnology and bionanotechnology[177] also show promise for the realization of a neural interface.

Today, nanotechnology is at a formative stage, yet it is maturing quickly. Between 1997 and 2005, government investment in nanotech research soared from $432 million to about $4.1 billion, and corresponding industry investment is now exceeding that of governments.[178] According to Luxresearch, total investment in nanotechnologies in 2005 reached $9.6 billion.[179] And the market for products based on nanotechnology will reach an estimated $3.7 trillion by 2014.

Nanomaterials, a subset of the nanotechnology market, offer tremendous opportunities for introducing a wealth of new products that could revitalize existing markets as well as solve major societal problems (e.g., cheap, clean drinking water and energy).[180] In the near term, nanotechnology will result in materials that are lighter and stronger. The potential economic and societal promise of nanomaterials has prompted US federal agencies participating in the Nanoscale Science, Engineering, and Technology Subcommittee (NSET) and US chemical companies to commit significant resources to nanotechnology research and development (R&D).[181] The race to research, develop and commercialize nanomaterials is global. Advances in nanomaterials promise to revolutionize broad domains such as high-performance materials, coatings, energy conversion and storage, sensors, electronics, pharmaceuticals and diagnostics.

Other governments are seeking to become major players in the nanotechnology domain as well. The Taiwanese government, for example, plans to invest NT$20 billion ($658 million US) between 2006 and 2010 in industries that apply nanotechnology to daily life. The hope is that Taiwan will develop into a global nanotechnology R&D centre.[182] Nanotechnology in Taiwan is one of six strategic daily-life S&T industries. The others include soft electronics, radio frequency identification (RFID), intelligent robots, intelligent vehicles and intelligent accommodation. It is estimated that by 2013, the manufacturing value of Taiwanese intelligent robots will hit NT$90 billion ($2.96 billion US), and that of RFID will hit NT$70 billion ($2.3 billion US).

176 http://humanitieslab.stanford.edu/2/290.

177 http://www.biomed.drexel.edu/BioNano/.

178 http://www.sciam.com/article.cfm.

179 http://asdn.net/ngc2007/presentations/mamikunian.pdf.

180 http://www.nano.gov/.

181 http://chemicalvision2020.org/nanomaterialsroadmap.html.

182 http://english.www.gov.tw/TaiwanHeadlines/index.jsp?categid=9&recordid=91955.

The military, economic and security implications of nanotechnology are considerable.[183] The potential capabilities that it will enable still appear to many as science fiction. Yet breakthroughs in almost every dimension of nanotechnology are bringing these capabilities closer to reality. As such, nanotechnology will likely represent an enabler that the CF capability development community cannot afford to ignore.

Recognizing the importance and potential impact of nanotechnologies on future capabilities, the US Army has provided $50 million to stand up the Institute for Soldier Nanotechnologies at the Massachusetts Institute of Technology (MIT) in Cambridge in order to improve warfighter protection. The institute's director, Dr. E.L. Thomas, predicts that within the next five to fifteen years, new capabilities such as battlesuit systems architectures and ultra lightweight nanorelief networks, self-assembled microtrusses and photopatterned nanocomposites will be possible.[184] These innovations will enable the development of new uniforms, better armour and improved sensors. Yet beyond 2020, it is expected that nanotechnology will have a significant impact on all types of weaponry, including smart chemical weapons, offering a unique combination of lethality and precision. Conventional and nuclear weapon production will also benefit. For example, the potential to produce nuclear weapons much more rapidly with a much lower detection threshold is possible.[185] In fact, some experts in the United States view global nanotechnology superiority at a level of importance equal to, if not exceeding, that surrounding nuclear weapon technology.

One important research area concerns mechanically active materials and devices based on reconfigurable materials. Such work promises to deliver smart materials that change shape when flexed. They will offer such capabilities as clothing that becomes armour or transforms into a reconfigurable cast that stabilizes an injury such as a broken leg. Yet a more remarkable shape shifting material—intelligent nanodust or claytronics—is now in early stages of development at Carnegie Mellon University.[186] The Carnegie Mellon claytronics project aims to understand and develop the hardware and software necessary to create a material which can be programmed to form dynamic three-dimensional shapes and which can interact in the physical world and visually take on an arbitrary appearance.

Invisibility is also being touted as a future possibility based on nanomaterial research into metamaterials.[187] Several researchers have already developed metamaterials with remarkable properties. Indeed, researchers in Canada have succeeded in creating metamaterials that have a negative index of refraction, able to focus electromagnetic waves with unparalleled precision.[188]

All areas of the energy market stand to benefit from new nano approaches as well. For example, new nanomaterials promise to enable the production of cheap and increasingly efficient solar panels that will rival conventional electricity production sources. New bio-nano techniques will offer significant improvement in biomass conversion to energy and potentially

183 http://www.afcea.org/signal/articles/templates.

184 http://web.mit.edu/ISN/.

185 http://www.afcea.org/signal/articles.

186 http://www.cs.cmu.edu/~claytronics/.

187 http://www.photonics.com/content/spectra/2006/July/tech/83278.aspx.

188 http://www.nserc.ca/news/2004/p040311_bio3.htm.

for direct hydrogen production. Even wind energy will benefit, as lightweight structural materials created with nano carbon fibres (carbon nanotubes) are integrated into the components of wind turbines.

Other applications include ultra-miniature robotic systems and nano-mechanical devices that have applications in manufacturing and in life sciences. These areas will develop slowly due to concerns over safety. Yet Canada's own National Institute for Nanotechnology (NINT)[189] will undoubtedly play a lead role in establishing national policies. From a defence perspective, given the significant disruptive potential offered by new nanotechnology developments, it will be important for the defence community to remain connected with policy decisions, particularly with respect to commercial technology transfer issues.

Such technological convergence is revolutionizing many technology dependant endeavours.[190] Access to space has become a commercial venture increasingly available to the public.[191] Given the excessive cost and acknowledged demand of space tourism, Buzz Aldrin, the second NASA astronaut to walk on the moon, has announced plans to conduct a space tourism lottery that would send the winner into space, thereby spreading the dream of extra-terrestrial travel beyond the super-wealthy.[192] Virgin Galactic's Richard Branson aims to develop a six-passenger craft that will offer sub-orbital space tourist travel this decade.[193] Indeed, the potential now exists for any well-funded group to gain access to space with a commercial launch of a micro surveillance satellite system.

Notably, a new space race is taking shape that will drive renewed innovation in space technologies. And an increasing number of global players are engaged in major space initiatives. Russia and China, for example, recently announced a joint mission to Mars.[194] Consequently, it is possible, perhaps even likely, that space will become an ever more prominent component of the future battlespace.

189 http://nint-innt.proteus.cisti.nrc.ca/main_e.html.

190 In their annual review of emerging technologies, Gartner has identified numerous technologies that will become a factor over the course of the next five to ten years. While a detailed review of these high-impact areas is beyond the scope of this paper, readers are encouraged to visit the Gartner's website for more details. The following are some of the areas projected to have high impact: Web 2.0, including social network analysis (SNA); Ajax; collective intelligence; Mashup; Real World Web (ubiquitous computing), including location-aware technologies; location-aware applications; Sensor Mesh Networks; new applications architectures, including event-driven architecture (eda); model-driven architecture; Corporate Semantic Web; application integration and platform middleware; electronics, including automotive electronics; compliance technologies; consumer technologies; content management; data management; enterprise speech technologies; human-computer interaction; identity and access management technologies; information security; infrastructure protection; Linux; networking and communications; PC technologies; portal ecosystems; printing markets and management; real-time infrastructure; semiconductors; server technologies; storage software technologies; telecommunications industry; technologies; vulnerability management; web services and related standards and specifications; web technologies; wireless hardware, software and services; wireless networking; and XML technologies. See http://www.technewsworld.com/story/57383.html.

191 Presently, while space tourism is a commercial reality, it is only within reach of the wealthy. Like most technology dependant endeavours, however, it is only a matter of time before the costs reduce to a point where they begin to be within the reach of the middle class.

192 http://www.reuters.com/article/scienceNews/idUnited StatesN1742589120070417.

193 http://www.virgingalactic.com/htmlsite/index.htm.

194 http://www.technewsworld.com/story/57383.html.

Technology-induced Societal Change

Technology is a key driver of societal change. Moreover, the pace of change is leading to societal disruptions, which in many cases are manifest in revised laws and policies. In fact, legal disputes are arising as a result of small groups using, or seeking to use, new technologies before the general public is aware of them and before any elected body has even considered the public policies which should surround them. In an era where blogs and other social networking tools offer platforms for individuals to openly and globally criticize governments and other officials, the tension between freedom of speech and state censorship will increase. Courts will therefore need to deal with situations that appear from our current frame of reference as outrageous and immoral,[195] perhaps on an increasingly frequent basis and often before a suitable regularity environment is in place. For this, if for no other reason, future-oriented exercises are of great practical importance. Accordingly, and in order to help avoid being taken by surprise and thus having to make rash judgments that often result in unintended consequences, systematic study of futures issues must become a routine part of all developmental activities.

The ongoing ethical debate over human embryo stem cell research provides an example of ongoing technology-induced policy disruption. Proponents of such work point to the great promise that stem cell research has for curing juvenile diabetes, Parkinson's, cancer, spinal cord injuries and many other diseases and conditions. Conversely, the current US administration, citing concerns over the moral implications of such work, has indicated an intent to veto recently introduced legislation[196] that loosens restrictions on the use of embryonic stem cells.[197] An equally disruptive development enabled by our globally connected society is the power it affords individuals and social groups in their fight against corruption[198] or even state- or national-level policies or activities. For example, the US Navy was recently sued over its use of sonar technology and the environmental harm that it causes.[199] Misinformation spread via new social network tools[200] can also incite international tensions. A Greek user recently posted a video on the YouTube site portraying Mustafa Kemal Ataturk, the founder of modern Turkey, and all Turkish citizens as homosexual, prompting the Turkish government to ban this site.[201]

Societal transformation via technological innovation is evident elsewhere as well. Already, the legal system is beginning to adapt to the impact of neuro-imaging and neuroscientific evidence in criminal law proceedings. Proponents foresee a significant impact not only on questions of guilt and punishment but also on the detection of lies and hidden bias and on the prediction of future criminal behaviour. Sceptics, however, fear that the use of brain-scanning technology as a mind-reading device will threaten privacy and mental

195 For example, researchers in California injected embryonic human cells into two-week-old fetal mice as they developed in the womb. When the mice matured, some human stem cells survived and became functional components of the mice's brains and nervous systems. See http://news.nationalgeographic.com/news/2005/12/1214_051214_stem_cell.html.

196 http://thomas.loc.gov/cgi-bin/bdquery/z?d110:SN00005:@@@L&summ2=m&.

197 http://www.technewsworld.com/story/56853.html.

198 http://www.transparency.org/global_priorities.

199 http://www.nrdc.org/media/pressreleases/051019.asp.

200 http://www.technewsworld.com/story/56458.html.

201 http://www.technewsworld.com/story/56184.html.

freedom. Some have suggested that a new concept of cognitive liberty will be required to mitigate these concerns.[202] Genetic liberty is also becoming an issue as advancements in biotechnologies and genetics offer an ability to identify genetic predisposition to specific diseases. This prompted the US House of Representatives to pass the *Genetic Information Non-discrimination Act*,[203] prohibiting improper use of genetic information in hiring and health insurance decisions.

Virtual reality developments will eventually lead to virtual economies and increasing segments of society that spend more and more time online. An emerging capability that is rapidly maturing due to the growing online community and automation tools is an ability to create increasingly customized worlds around us. A more significant outcome of the increasing numbers of people online is the generation of stigmergic behaviours.[204] Tools such as e-mail and web logs or blogs, for example, enable people to work together no matter where they are located. Furthermore, time-separated collaboration (stigmergy) is possible, as evidenced by the growing use of wiki tools.

Still, digital security will become an increasing area of concern, as more personal and private information is digitized. Recently, the US Transportation Security Administration (TSA) discovered that an external hard drive containing personnel data (including name, social security number, date of birth, payroll information, financial allotments and bank account and routing information) was missing from a controlled area at the Headquarters Office of Human Capital.[205] The implications for institutions are significant. Along with the security implications, failure to safeguard digital information could carry financial risks. The TSA has had to provide one year of free credit monitoring and identity theft insurance up to $25,000 to assist employees in the event they are a victim of identity theft. Military systems will not be immune to these risks and challenges.

Another area that will continue to challenge societies is the ease with which digital data can be copied, shared and manipulated. Today, image and video manipulation is possible with a few keystrokes or clicks of a mouse and is available to anyone. These inexpensive capabilities, combined with near instantaneous world-wide dissemination over the Internet, offer opportunities for misinformation, deception and fraud, whether intentional or otherwise. The ability to access this information via the web, complicated by e-mail traffic from colleagues, will increase the need for due diligence in verifying sources. It will become impossible to believe anything seen, heard or read in the popular media or online unless it is corroborated by numerous unique, distinct and trusted sources. Unfortunately, it is becoming all too easy for legitimate sources to “lift” content (accurate, misleading or just plain wrong) in an instant in our web-connected world. Even scientific journals are not immune to deception, as the growing “publish-or-perish” paradigm forces failing programs to take drastic measures.[206] Web logs or blogs will only serve to aggravate the situation.

202 http://www.nytimes.com/2007/03/11/magazine/11Neurolaw.t.html.

203 http://thomas.loc.gov/cgi-bin/bdquery/z?d108:s.01053:.

204 Pierre-Paul Grasse introduced the concept of stigmergy in the 1950s to describe the indirect communication among individuals in social insect societies.

205 http://www.tsa.gov/datasecurity/b.

206 http://blog.sciam.com/index.php?title=journals.

Issues of inappropriate data and information manipulation notwithstanding, network-enabled social collaboration remains a powerful and beneficial capability that will most likely continue to grow in popularity and importance. Many large government organizations will likely tap into this social phenomenon. NASA, for example, has already announced a new open-source project called CosmosCode, which aims to recruit volunteers to write code for future space missions.[207]

Such openness and transparency is likely be resisted within a defence environment. Yet there is no reason why similar social collaboration tools could not be implemented to tap into the collective wisdom of current serving members of the CF. Failure to implement such social collaborative tools could result in security disruption, as private sector mass collaboration may well out-compete traditional institutional bureaucracies.[208] Recognition of the power afforded by network collaboration has led some corporations to develop applications that enable "crowd sourcing."[209] Furthermore, the net has even become the new political battlefield[210] for the upcoming US presidential election.[211]

Network-based collaboration is hardly a new phenomenon. However, momentum is gaining, as new so-called Web 2.0 applications proliferate. These applications start with very little information but provide easy-to-use tools that encourage users to contribute material and expand content. Over time, a Web 2.0 application evolves, and the users essentially become the administrators, thus establishing a self-organizing site. A 2006 Booz Allen Hamilton study found that social networking was a massive phenomenon applicable to all users regardless of age, social class, gender or education. More than half of all Internet users already rely on advice from a massive worldwide user community, indicating a wide acceptance of new ways to form opinions and make buying decisions. Privacy concerns have also diminished. Indeed, while 70% of MySpace users in the UK create their own content to share, only 39% restrict public access to materials intended only for themselves or their acquaintances.[212]

In fact, despite resistance to implementing open collaborative initiatives, it may become necessary for government organizations to provide open access to publicly funded research. Several organizations such as the Alliance for Taxpayer Access are actively seeking such access, claiming that public money should yield public benefit.[213] The scientific community has already begun to provide open access to their information, at least to colleagues, through the wiki for professionals. Such a workspace will enable real-time knowledge exchange and exploration by combining information in databases with literature so that it all appears to be a single database from a user's perspective.[214] Open access to all this information, coupled with the addition of text mining software, will allow users to probe links within the data, thus facilitating detailed analysis. Such a "liberation of information" will empower individuals while

207 http://colab.arc.nasa.gov/.

208 http://www.cio.com/article/107253/Why_You_Should_Collaborate.

209 http://www.businessweek.com/innovate/content/jul2006/id20060713_755844.htm.

210 http://www.technewsworld.com/edpick/56424.html.

211 http://www.technewsworld.com/story/57041.html.

212 http://www.boozallen.com/publications/article/29354647.

213 http://www.taxpayeraccess.org/.

214 http://www.popsci.com/popsci/how20/58c7db3c57f61110vgnvcm1000004eecbccdrcrd.html.

at the same time reducing government monopoly on information. Indeed, it may become a necessity for organizations to provide social networking tools to their personnel. Failure to do so may increasingly be seen by in-house staff as an attempt to censor their activities. To some degree, this situation is being played out in the US military, as access to social networking tools has been restricted due to bandwidth and security concerns.[215]

While bandwidth and security restrictions may be legitimate in a military context, such measures may become increasingly intolerable to individuals who expect social collaboration and communication tools to be made available to them. Recently, Digg.com users posted links to a code that allowed software developers to copy encrypted content from HD-DVD discs. The code's creators, Advanced Access Content Systems, demanded that the Digg.com administrators remove the links. While the site's administrators cooperated with the request, the site's users rebelled.[216] Digg's site was covered with thousands of links to the code and free speech protest statements. Ironically, millions have now seen the HD-DVD code, and a Google search of the first few digits of the code results in links to over 1.6 million copies of the complete code. This social rebellion has forced Digg's administrators to abandon its attempts to remove the code and instead to develop a legal position in preparation for inevitable litigation by the code's creators. In the future, any attempt by authority to stifle user communication within these emerging Web 2.0 collaborative environments may ironically lead to greater proliferation of the information that they initially attempted to restrict.[217]

Increasingly, the proliferation of open social collaborative network platforms will enable the small to become powerful. Civilian network-enabled operations capabilities will likely grow in sophistication and power, rivalling anything that can be implemented by large institutional armies due to their bureaucracies. This condition of continuously available computing will undoubtedly cause societies to morph in unexpected directions, as people find innovative ways to put these commercial and open-source technologies to use in their social lives. At some point, the underlying hardware and software that enables this ubiquitous mobile[218] social networking will become so unobtrusive and commonplace that it will become part of

215 http://www.technewsworld.com/edpick/57400.html.

216 http://blog.digg.com/?p=74.

217 This phenomenon is becoming known as viral marketing, which clearly can have positive advertising benefits but negative consequences if attempting to protect sensitive information. There are growing opportunities, however, to data-mine these flourishing connections. Intelligence agencies are seeking to track insurgent groups with social network mapping tools, for example. While this raises privacy issues, it is likely that the convenience afforded by social networking will trump these concerns. However, with the proliferation of camera and videophones, the biggest threat to privacy in the future may not be the government, but rather your next-door neighbour. The potential implications for social disruption seem profound.

218 Speaking at a conference in 2006, Sir David Brown, Chairman of Motorola, indicated that the mobile industry had no idea how successful they would become. He admitted that in the mid-1980s, the mobile phone industry estimated that by the year 2000, there would be a market for about 900,000 mobile phones worldwide. At the turn of the millennium, he said, 900,000 phones were being sold every 19 hours.

the fabric of society and will cease to be viewed as high-tech. At that point, being cut off from the network will be a traumatic event.[219]

The Army's capability development community will need to be aware of this issue and its human resources implications. Potential recruits in the year 2021, the date for Army of Tomorrow full operating capability, are presently four to eight years old. They will undoubtedly have well developed expectations of network-enabled social collaboration availability. As such capability development will need to cater to this expectation. Moreover, an ability to operate in this environment will be a trait in high demand amongst recruits since the Army of Tomorrow adaptive dispersed operations (ADO) concept envisions a ubiquitous network environment. That said, balancing security requirements with availability demands will continue to be a challenge for military system implementation.

Military Technology Change

The changes resulting from the proliferation of networking within the commercial sector are influencing the interface between Canadian society and the military. Communication between deployed personnel and their families, and society in general, has been improved significantly through initiatives such as DNDTALK,[220] which is promoted as a place where family members can post messages to deployed personnel. It features blog capabilities and will soon provide podcasting tools that will allow audio messages in MP3 format to be posted.

Military blogging is a rapidly developing trend. The United States and Iraq top the list of countries with Milblogs, with 1123 and 386 sites respectively. Canada has 18 Milblogs[221] listed on the site. The Canadian-Forces blog[222] serves as a reservist recruiting site. Others provide blogging tools for military families.[223] While these sites may enhance troop morale, they are not without their challenges. Providing access to these and other services requires significant communications bandwidth. Operational imperatives obviously will demand that available bandwidth be prioritized for mission-specific use. Insufficient reach-back bandwidth, therefore, could jeopardize troop morale in the future, as more and more individuals become used to being in constant contact, often in real time.

Beyond the social benefits provided by advanced information and communications technology (ICT) networking, these technologies are increasingly being applied to extend the life of legacy systems by allowing them to be used in new and innovative ways, including dispersal with greater situational awareness and superior cooperative engagement potential. Newly integrated ICT also provides better engagement capabilities. For example, new ICT-based

219 The importance and proliferation of networking in developing countries cannot be underestimated. For example, the United Villages Project uses buses and motorcycles equipped with wi-fi to deliver web content to remote rural villages in the developing world. In rural India and parts of Rwanda, Cambodia and Paraguay, the vehicles offer web content to computers with no Internet connection. Already, significant portions of the developed world are seeking to make network access mandatory. For example, the 25 European Commission member states and nine accession countries have all signed up for a plan that could make accessibility in e-procurement mandatory. See http://www.unitedvillages.com/ See also http://europa.eu/rapid/pressReleasesAction.do?reference=IP/06/769&format=HTML&aged=0.

220 http://dndtalk.com/Joomla/.

221 http://www.milblogging.com/result.php?country=Canada&mode=advance.

222 http://canadian-forces.blogspot.com/.

223 http://military.families.com/blog/category/357.

fire control systems comprising computers, sensors and software can offset deficiencies in armour protection with improved first hit/kill probability. Furthermore, as robotic vehicles enter service by 2021, they could draw fire or spot targets, allowing legacy systems to engage and dominate while not having superior firepower or armour. New materials research may offer opportunities to increase the service life of the main chassis of major weapons platforms; however, it would be unreasonable to expect the integrated ICT components to have a service life greater than several years. This is not because they would fail but rather they would become obsolete due to the exponential pace in development of the technologies. This situation demands a modular plug-and-play upgradeability path that allows new ICT to be easily incorporated without major retrofit into legacy systems.

While the development and expansion of the Internet characterizes and defines the 21st century information age, the basic tools of warfare (e.g. tanks, trucks, direct fire systems and missiles) remain remarkably similar to their industrial age predecessors. Although the integration of 21st century information technology into vehicle systems is notable, their basic physical performance characteristics are only marginally better than those of their Cold War predecessors. Propulsion systems and other mechanical components that define physical performance are progressing at much slower rates than information technology or its uptake. In fact, it will be primarily within the realm of information technology—with exponential improvements in rapid computation, simulation, situational awareness, targeting, surveillance and precision—that the greatest increases in vehicle effectiveness will be witnessed.

Technology is currently being leveraged to gain the full strategic and tactical advantage of a mobile, agile and flexible force. This has led many armies to focus much of their development efforts on fleets of lighter armoured vehicles that provide a credible and effective fighting force. While recent experience in the current operating environment has increased emphasis on protection with regard to the firepower-mobility-protection triangle and the need for heavy armour levels of protection in countering the IED threat, advances in materiel design and manufacture and information technology will be leveraged to enhance the protection of lighter weight forces. In this sense, survivability encompasses all successive layers of protection, from mobility and stealth to signature reduction and soft-kill defensive aids suites (DAS), to hard-kill DAS, to improved armour, to spall suppression systems.

A revolution in war has been underway for nearly three decades.[224] This revolution is characterized by the emergence of all-weather precision war, the advent of stealth, the rise of unmanned systems, the tactical and operational exploitation of space and the emergence of early forms of network-based warfare and joint force integration. The rate of change in military capabilities will increase substantially over the next couple of decades. Precision-strike capabilities will continue to increase in reach, scale and sophistication. More advanced forms of stealth are in development. Sensors and battle networks will continue to increase in capacity and sophistication. Unmanned systems will become an increasingly important component of force structures. Yet the question of whether a critical mass of these capabilities will diffuse to potential competitors or whether the United States will remain the dominant military technological power remains unclear.

224 http://www.csbaonline.org/4Publications/PubLibrary/R.20041201.RevInWar.

Notably, the longer-term utility of legacy systems has been questioned. Defence analysts Michael Vickers and Robert Martinage contend that the power of smart munitions (which can be fired remotely or shoulder launched) is outstripping the protection afforded by speed and armour.[225] Similarly, George and Meredith Friedman contend that conventional weapons platforms such as tanks will have difficulty surviving in a world of precision-guided munitions.[226] These contentions are underscored by trends within the protective armour R&D community, which is turning to explosive reactive armour as a potential means to defeat smart munitions.

Commercial technologies are increasingly becoming available at much lower costs and often with greater operational functionality than currently fielded militarized equivalents. While these commercial systems sometimes lack certain security features, they are being purchased by troops before they deploy to theatre. For example, US units and/or soldiers have been purchasing commercial Garmin GPS products for use while in theatre. Doing so has ensured that at least one person per patrol and sometimes everyone has GPS capability. This situation will likely continue, as commercial innovation provides capabilities more quickly than military procurement programs can respond.

More significantly, newer navigation devices have become inexpensive commodities that anyone, including adversaries, can obtain. These sophisticated compact personal devices offer advanced functions, including point-to-point navigation with turn-by-turn directions, all displayed on a three- to four-inch touch map screen complete with voice instructions.[227] The commercial systems are designed to be portable and rugged with extended battery operation. They can even be integrated into a variety of cheap off-the-shelf commercial products, thus facilitating the creation of inexpensive precision weapons. When combined with commercially available communications technologies, they offer situational awareness capabilities rivalling those available to current deployed military systems. It is likely that the European Union commercial satellite navigation system, Galileo, will add to the robustness of commercial navigation offerings. In fact, Galileo will offer advantages over its contemporary military counterparts (the US GPS and the Soviet GLONASS).

China is also seeking entry into the satellite navigation sector. On 14 April, 2007, China launched a COMPASS navigation satellite, its fourth satellite launch since 2000. And Beijing reportedly plans to provide national coverage and coverage for some neighbouring countries by 2008.[228] Eventually, it is expected that Beijing will expand its satellite program to provide global coverage.

Commercial innovation is providing publics with other sophisticated capabilities previously available only to advanced militaries. Israeli-owned ImageSat International, for example, offers customers the opportunity to task its EROS-A imaging satellite and download its data in total secrecy with few, if any, restrictions.[229] The service essentially provides private customers with their own reconnaissance satellite at low cost. Now the freely available

225 http://www.csbaonline.org/4Publications/PubLibrary/R.20041201.RevInWar, p. 80.

226 http://www.holtzbrinckpublishers.com/academic/Book/BookDisplay.asp?BookKey=566248.

227 http://www.gpsworld.com/gpsworld/article/articleDetail.jsp?id=300303.

228 http://www.spacedaily.com/reports/China_Launches_Compass_Navigation_Satellite_999.html.

229 http://imagesat.pionet.com/?catid={38D9FD69-CE40-4E27-8F6D-85D35E50AFEF}.

Google Earth[230] and Map applications provide anyone with an Internet connection and a contemporary computer with powerful, free geographic tools and global satellite mapping coverage. The private satellite industry is becoming so advanced and pervasive that many advanced militaries, including the US military, now rely upon it to provide some of its imaging and much of its communications needs.

Other dramatic shifts in commercial innovation lie in the robotics sector. Rodney Brooks, director of a large-scale US computer science and artificial intelligence lab, indicates that ten years ago, 90% of his group's funding was provided by the Defense Department, whereas today it is less than 25%.[231] In short, sophisticated robotic technology is proliferating commercially rather than solely in the military domain.

The confluence of all these trends could lead to new forms of war within the dimensions of space, information and biology. The conduct of land warfare could shift from a regime characterized by mobile, combined-arms and armoured forces to one dominated by much lighter, stealthier and information-intensive forces that make heavy use of robotics. Increased commercial and military use of space could lead to the emergence of a wide range of offensive and defensive space control capabilities. Computer network attack tools and radio frequency weapons could be widely used to assault information infrastructures and information-intensive forces. Designer biological weapons and the emergence of biological operations could also figure prominently. Clearly, a failure to hedge capability development efforts to deal with these possibilities represents a significant future risk.

Human Factors Implications

As society changes, the skills that citizens need to address challenges also change. In the early 1900s, a person who had acquired simple reading, writing and calculating skills was considered literate. Today, it is expected that all students must read critically, write persuasively, think and reason logically and solve complex problems in mathematics and science. According to an enGauge 21st Century Skills study,[232] the driving force for the 21st century will be the intellectual capital of citizens. On the military front, soldiers will need digital age proficiencies in order to thrive on a digital battlefield. And the military training system must make parallel changes to prepare soldiers for this environment. In particular, the training system must understand and embrace the skills demanded by changing technology in the 21st century.[233] These skills include:

- **Visual and Information Literacy**. The graphic user interface of the World Wide Web and the convergence of voice, video and data into a digital format have increased the use of visual imagery dramatically. Advances such as digital cameras, graphics packages, streaming video and common imagery standards allow for the use visual imagery to

230 http://earth.google.com/.

231 http://www.fastcompany.com/magazine/104/open-debate-extra.html.

232 The enGauge 21st Century Skills were developed through a process that included literature reviews, research on emerging characteristics of the Net-Generation, a review of current reports on workforce trends from business and industry, analysis of nationally recognized skill sets, input from educators, data from educator surveys and reactions from constituent groups. See http://www.metiri.com/features.html.

233 This list of 21st century skills is adapted from the enGauge 21st Century Skills study. See http://www.ncrel.org/engauge/skills/skills.htm.

communicate ideas. Good visualization skills are required to be able to decipher, interpret, detect patterns and communicate using imagery. Information literacy includes accessing information efficiently and effectively, evaluating it critically and competently and using it accurately and creatively.

- **Cultural Literacy and Global Awareness**. As the world becomes increasingly wired and interconnected, the resulting globalization of commerce, trade and conflict increases the need for cultural literacy. In such a global economy, with interactions, partnerships and competition from around the world, there is a greater necessity for knowing, understanding and appreciating other cultures, including the cultural norms of a technological society.

- **Adaptability/Managing Complexity and Self-Direction**. The interconnectedness of today's world generates unprecedented complexity. Globalization and the Web are inherently complex, accelerating the pace of change in today's world. Interaction in such an environment requires individuals capable of identifying and reacting to changing conditions independently. Indeed, individuals must be self-directed learners who are able to analyze new conditions as they arise, identify the new skills that will be required to deal with these conditions and independently chart a course that responds to such changes. They must be able to take into account contingency, anticipate change and understand interdependencies within systems.

- **Curiosity, Creativity and Risk-taking**. Individuals today are expected to adjust and adapt to changing environments. Inherent in such situations is a curiosity about the world and how it works. Researchers now understand how the very structure of the brain can be changed through intellectual pursuits. Curiosity fuels lifelong learning, as it contributes to the quality of life and to the intellectual capital of the country. Equally important is risk taking—without which, there would be few quantum leaps in discoveries, inventions and learning.

- **Higher Order Thinking and Sound Reasoning**. For decades, reports have been calling for higher order thinking and sound reasoning in school curricula. This includes thinking creatively, making decisions, solving problems, seeing things in the mind's eye and knowing how to learn and how to reason. Sound reasoning enables individuals to plan, design, execute and evaluate solutions—processes that are often carried out more efficiently and effectively using technological tools.

- **Teaming and Collaboration**. The rapid pace of today's society and communications networks has caused, and enabled, a shift in the level of decision-making down to the individual. At the same time, the complexity of today's world requires a high degree of specialization by decision makers. This demands the teaming of specialists to accomplish complex tasks in ways that are efficient, effective and timely. Information technology plays a key role in the ease with which individuals and groups collaborate. Email, faxes, voice mail, audio and video conferencing, chat rooms, shared documents and virtual workspaces can provide timelier, iterative collaborations.

- **Personal and Social Responsibility**. Emerging technologies often pose ethical and values dilemmas. As technical complexity increases, ethics and values must guide the

application of science and technology at the personal, community and governmental levels. Individuals must grasp this responsibility and contribute as informed citizens at all levels.

- **Interactive Communication**. In our wired, networked society, it is imperative that individuals understand how to communicate using technology. This includes asynchronous and synchronous communication such as person-to-person email, blog and wiki interactions, group interactions in virtual environments, chat rooms, multi-user gaming environments, interactive videoconferencing, phone/audio interactions and interactions through simulations and models. Such interactions require knowledge of etiquette often unique to that particular environment. Information technologies do not change what is required for high quality interactive communications. Yet they do add new dimensions—scheduling over time zones, cultural diversity and language issues—that need to be mastered so they become transparent (e.g. scheduling over time zones, cultural diversity, and language issues). Otherwise, such technologies may interfere with, rather than enhance, communication.

- **Prioritizing, Planning and Managing Results**. High levels of complexity require careful planning, managing and an ability to anticipate contingencies. This means more than simply concentrating on reaching the main goals of the mission or monitoring for expected outcomes. It also requires the flexibility and creativity to anticipate unexpected outcomes as well.

Conclusion

Military technologies will undoubtedly continue to be augmented with improved intelligence, speed, range, stealth, lethality and autonomy in what amounts to a continuous race to outpace perceived threats. Indeed, despite the inherent inability to predict the future, there is sufficient trend data to suggest that technology (primarily commercial) will continue to advance exponentially and converge, barring an unforeseen catastrophe. This offers the potential for small, well-funded groups to achieve asymmetric technological advantage in niche areas, thus threatening current western military superiority.

Foreseeable advances in artificial intelligence, computation, simulation, communication, sensors, robotics and portable power are just beginning to influence today's land force capability development thinking. Unfortunately, given the snail's pace at which major new system capabilities are delivered, complicated by a procurement pipeline that is fully subscribed with mainly traditional equipment and platforms, it will be difficult to respond in a timely manner to the continuing rapid technological change, let alone to a potential (perhaps looming) security disruption caused by new commercial technological breakthroughs.

It is still unclear whether failed and failing states or terrorist groups and organized crime syndicates will successfully incorporate these new high-tech capabilities into their operations in sufficient quantity to threaten western military superiority. Already though, al Qaeda has proven proficient at harnessing the power of networking technologies and adapting commercial technology for use as weapons (such as the 9/11 use of commercial jet liners as cruise missiles). Furthermore, knowledge of what commercial technology is able to do, and where to obtain it, is public domain on the Internet. And it is easily ordered over the Internet

with next day delivery by one of many international courier services. Indeed, asymmetric attacks using simple commercial technology, such as cell phones or IR remote controls, have already occurred. Furthermore, as recent experience with suicide bombers shows, these ad hoc technological threats need only be designed to work once in order to be an effective weapon.

The key issue for force development, however, is to determine to what extent the potential offered by rapidly changing technological developments will influence capability requirements in five to ten years. These time frames are particularly important since the capital procurement history of DND suggests that many procurement decisions made today are unlikely to be fielded much before 2015 and, in some cases, not until 2020 and beyond.

Future-focused projects such as autonomous systems (robotics) need to be entered into the procurement pipeline as soon as possible. It is imperative that the capability development priorities stemming from Army of Tomorrow work remain informed by the pace of technological change in the broad domains outlined above. Indeed, failure to hedge development activities to cover the potential threats offered by the onslaught of advanced commercially available technologies represents a serious risk to tomorrow's land operations.

Chapter 3

Transformation and the Army of Tomorrow

By Major Andrew B. Godefroy

In September 1997, the 1st Canadian Division Headquarters and Signals Regiment (1CDHSR) held an internal planning session to assess the challenges the Army was then facing as well as identify its immediate priorities and future development. The commander and host for the session, Major-General Crabbe, stressed to the gathered audience that he wanted a frank assessment of the issues brought forth in an unrestrained brainstorming manner. Most importantly, he wanted everyone to think "outside the box."[234]

The event was simply one of many resulting from the catalyst of change then sweeping through the Army. After years of sustaining a tremendous operational tempo, while facing increased internal and external political and financial pressures as well as a constant reduction in both resources and personnel, the Army had reached something of an institutional low point. Though its soldiers had with very few exceptions performed exceptionally well and now constituted one of NATO's largest professional veteran forces in operations other than war, its internal organization and structure was failing as core pillars suffered atrophy. The Army's capability development and strategic planning was weakened by a lack of vision and the existing environment of perpetual crisis management, while the high operational tempo had disrupted the training of the Army and its succession planning. Meanwhile, the development of the future army languished without a strategic framework, open professional debate on army issues and a lack of devoted resources for conceptual and doctrinal design. It was an exceptionally difficult time for the institution, but it was not for lack of recognition of the problem. There appeared simply little opportunity for military enterprise and conceptual change to take place.

Yet military enterprise and conceptual change were needed within the Army. At the same September 1997 planning session mentioned above, Brigadier-General M.K. Jeffery, then the Commandant of the Canadian Land Forces Command and Staff College (CLFCSC), presented a critical overview of the existing land force development process and suggested that unless soon repaired, the Army might lose what remained of its already limited combat effectiveness. He noted that in the past, the Army's force development processes were very linear and far too long, meaning that a full cycle of the capability development process could never be completed before the strategic environment changed. This was especially the case after the end of the Cold War, as the international security environment became increasingly dynamic and unpredictable.

Despite a seemingly endless list of immediate priorities, Brigadier-General Jeffery successfully advocated to the Chief of the Land Staff, Lieutenant-General Bill Leach, the need for resources to be invested in the conceptual and doctrinal design of future army capabilities. The first capstone products of this "army transformation" begun in 1999 were the publication of a new army strategy in May 2002, followed by a new force employment concept for the

234 DND. 1180-1 (Coord). Record of Discussions—Comd 1st Canadian Division's Internal Planning Session (held 22-24 September 1997), dated 25 September 1997, 1.

of a new army strategy in May 2002, followed by a new force employment concept for the existing "Interim Army" in March 2004.[235] These products and the efforts that lay behind their production effectively defined the current Army as well as re-established a coherent capability development process within the land force. More importantly, perhaps, it created the conditions needed to initiate a comprehensive examination of the future security environment and the Canadian Army that would be needed to operate within it over the next ten to thirty years.

Army Strategic Concepts—Moving Beyond the Cold War

Although a successful legacy in combat development existed, few could deny that the Land Force Capability Development Process had atrophied since 1994.[236] The new White Paper on Defence released by the government that year instigated a series of budget, resource and personnel rationalizations, as political leaders struggled to find the elusive peace dividend that was expected to follow the collapse of the Soviet Union and the Warsaw Pact. At the same time, the Army was significantly challenged to constantly sustain a high operational tempo. By 1994-1995 the Army was deploying just to the Balkans alone over 2000 personnel in two Canadian Battalion groups (CANBATs), a logistics battalion group (CANLOGBAT) as well as other additional mission support roles. Much of the Army's existing equipment had been deployed on operations in this theatre with little rotation in excess of forty months, seriously shortening its service life while expediting its rust out. At the same time, the Army was reorganizing and rationalizing its entire force structure, downsizing its capabilities as funding remained constrained. The end result was the inability to adequately sustain what remarkably became considered "luxuries" in the Army's structure: strategic concepts organizations, force development organizations and the like. Yet without them, the Army could not determine how it should evolve as well as where it needed to focus its precious resources first.

The reduction of formal, long-term strategic forecasting in army combat development during the mid-1990s and the absence of dedicated conceptual development had restricted the overall debate concerning the future direction of the Canadian Army. Fortunately, senior leadership recognized this and steps were taken to ameliorate the situation somewhat in 1997, most notably through the creation of the Directorate of Land Strategic Concepts (DLSC) in Kingston. Located away from NDHQ and within the Land Force Doctrine and Training System (LFDTS), a small nucleus of experienced soldiers were tasked with assessing the future security environment, emerging technologies and future land warfare concepts.

As DLSC began its own work, manoeuvre warfare theory—an increasingly popular concept amongst the four armies America, Britain, Canada and Australia (ABCA) community at the time—dominated Canadian doctrinal thinking and eventually formed the basis of the current Army's doctrinal design. Though a generally sound approach, some criticized the decision

235 Department of National Defence, *Advancing with Purpose: The Army Strategy* (Ottawa: Commander, Land Force Command, May 2002); and, *Purpose Defined: The Force Employment Concept for the Army* (Ottawa: Chief of the Land Staff, 31 March 2004).

236 For a survey history of the subject, see Major Andrew B. Godefroy, "Chasing the Silver Bullet: The Evolution of Capability Development in the Canadian Army," *Canadian Military Journal* Vol. 8, No. 1 (Spring 2007), pp. 53-66.

to pursue a concept that the Canadian Army had had little chance to appreciate from a strategic point of view and little chance of ever executing in the foreseeable future. A senior army officer later wrote in the *Army Doctrine and Training Bulletin* that the whole approach was ill conceived and based on a gross misinterpretation of the attrition-versus-manoeuvre dichotomy that led to its subsequent misapplication in the formulation of later operational and tactical doctrine. Employing considerable evidence in his well-thought-out case, the officer lamented that the confusion "has produced doctrine as dangerously narrow as *offensive a l' outrance*".[237] Manoeuvre warfare doctrine was not, some argued, a vision for the Army of Tomorrow, and some wondered if it was even appropriate for the Army of Today.

Though a seemingly harsh assessment, the criticism carried some weight and was reflective of wider concerns about how the Canadian Army intended to pursue capability development in the future, as transformation took hold of the CF writ large. The purpose of Canadian Army land strategic thought, its capstone concepts and doctrinal designs was not only to instruct its commanders on how to fight and win Canada's land wars but also to educate them about how they should think about how to fight and win Canada's land wars. It was very difficult, however, to think and act in a uniquely Canadian context, when leaders and soldiers alike had to rely almost entirely on foreign interpretations of the art of land warfare or on often-incomplete Canadian primary sources and the temporary corporate knowledge of those actively engaged in the process. Such a state of affairs existing within the Canadian school of thought had at times a negative effect on its overall success, led to loss of ideas and the duplication of efforts and even led others much less knowledgeable and lacking foresight to question the legitimacy of the entire process and the organizations charged with its execution.

Still, these intellectual and institutional challenges actually encouraged rather than discouraged the creation of a renewed and effective capability development process within the land force, anchored by robust strategic conceptual and doctrinal design. The dynamic international security environment of the mid-1990s necessitated and instigated rapid change within the Army. But crisis management could no longer serve as the method for army evolution. It was time for a considered strategic approach oriented on a future vision, and the first step was to identify a clear and common view of how that future vision would be realized.[238]

The New Army Strategy

The Army had last conducted a fundamental review of its strategy in 1997 during a small number of meetings, including the Army Senior Officer's Retreat, as well as various internal reviews such as the 1CDHSR conference mentioned above. These reviews resulted in the formal recognition of the symbiotic relationship that existed between the armies of today, tomorrow and the future, and the orientation of the existing land force capability development guidance towards the conceptualization of Canada's future Army. From this position, army force developers could then more easily and successfully identify and design the middle

237 Lieutenant-Colonel Ian Hope, "Misunderstanding Mars and Minerva: The Canadian Army's Failure to Define an Operational Doctrine," *The Army Doctrine and Training Bulletin: Canada's Professional Journal on Army Issues* Vol. 4, No. 4 (Winter 2001-2002), p. 16.

238 DND, *Future Army Development Plan* (Kingston: DLSC, 8 March 1999), p. 1.

section—the "Army of Tomorrow"—that would be like the current Army to the conceptual Army of the Future.

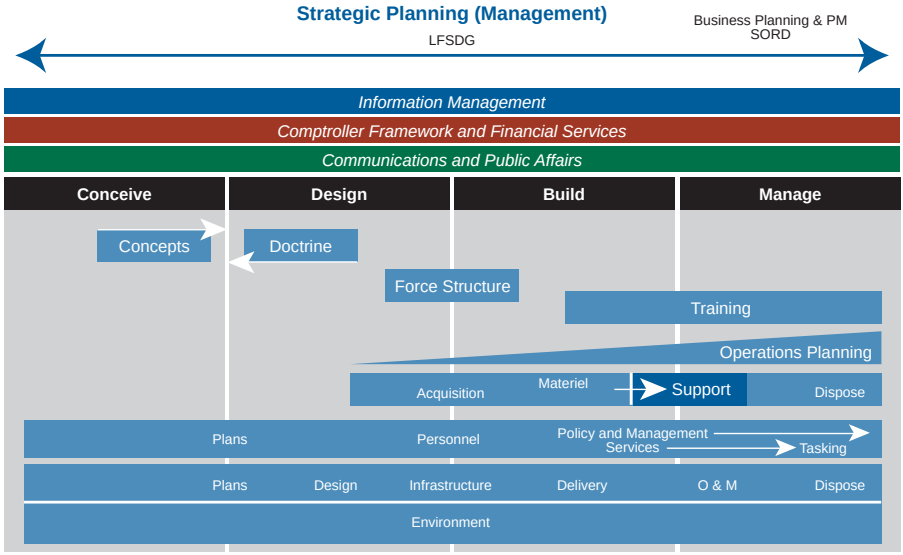
Figure 3-1: The Three Army Model, c. 1998

The Army's new approach broadly aligned land force development ideas within the commonly accepted CF three-horizon future security and force planning concept. This concept divided future time frames into short term (0-5 years), mid term (5-10 years) and long term (10-30 years) periods of assessment. The three-army model also fit in well to the department's annual Defence Planning Guidance (DPG), the core guidance and planning process that identified the Army's strategic capability requirements as well as the resources allocated to acquire and sustain them.

The Army published its *Land Force Strategic Direction and Guidance* (LFSDG98) in 1998, which served as a comprehensive statement outlining the necessary direction of change for the Army and the outline of a plan to achieve that change.[239] LFSDG98 was accompanied by the production of a *Future Army Development Plan* (FADP), which provided a framework for focusing force development activities through a series of phases of investigation. This document also explained the revived land force management process (currently known as the Land Force Capability Development Process), how it linked to other DND as well as allied force development processes, and how the new approach would likely impact on army concepts, doctrine, training and standards. Finally, the document outlined specific plans for army experimentation, operational research and options analysis. Overall, the FADP document revealed a serious intellectual and professional commitment by senior army leadership to the creation of cogent, relevant and sustained future army development.

239 DND, *Advancing with Purpose: The Army Strategy*, p. 7.

Figure 3-2: Land Force Management Process, c. 1998



LFSDG98 was updated in the spring of 2000 followed by a more fundamental review known as the Army Strategic Refocus in the fall. This resulted in the publication of an updated Land Force Strategic Direction and Guidance (LFSDG01) as well as the initiation of a series of strategic planning sessions devoted to options development and the identification of short- and long-term goals. An army transformation study was also initiated to identify requirements for modernization as well as determine resource flexibility within the department. One of the major conclusions of this study was the need for an interim sustainable force structure model to lay a firm foundation for the transformation of the Army.[240]

Major-General Jeffery was promoted to Lieutenant-General and appointed the Chief of the Land Staff (CLS) on 8 August 2000. Already an advocate for Army transformation, he concluded that if the Army was to indeed evolve beyond its Cold War and early post-Cold War constructs and remain relevant both in the emerging security environment as well as to the needs of the CF and national security, short-term savings were needed to ensure a tangible investment towards achieving longer-term goals. This decision allowed the Army of Today to continue functioning while preparing the institutional ground for a transformation towards the Army of Tomorrow. As an expedient to achieve this end state and knowing that the Army of Tomorrow might still be as much as a decade or more away, army senior leadership first ordered the creation of a new strategy to serve as a vision and roadmap to take the Army through the stages of transformation that were envisioned.

The terrorist attack on the United States on 11 September, 2001 dramatically shifted the strategic direction of the North American defence and the NATO alliance. The priorities of the Government of Canada (GoC), DND and the Army were all likewise affected. Specific goals of the LFSDG were completed, dissolved or, in some cases, simply overtaken by events, and

240 Ibid., p. 9.

the timely production of a new strategy became even more important for the Army. Not only did the Army need to respond to a new and more dangerous future security environment, it also had to clearly explain how it planned to evolve within this new strategic context. Therefore, the new army strategy had to define not only the Army of Today, but also how it intended to build the Army of Tomorrow with a view to the Army of the Future. And it had to do this knowing that the Army's future would very likely be dynamically shaped by the impending experience of deployment into hostilities in Afghanistan.

After a further series of army experiments and analyses between late 2001 and early 2002, the new army strategy was released by the Chief of the Land Staff and Commander Land Force Command. Titled, *Advancing with Purpose: The Army Strategy*, the May 2002 publication also carried the encouraging subtitle, "One Army, One Team, One Vision." Building on the tremendous amount of effort that took place in land force development between 1997 and 2001 to set the conditions for transformation, the new strategy also marked the first post 9/11 capstone document designed to articulate the nature and future direction of the Canadian Army. More importantly, it provided the holistic baseline from which more detailed work could then begin, starting with the evolution of the current Army into the Army of Tomorrow while tying it conceptually to the Army of the Future. The three-army model for future force development originally envisioned by Major-General Jeffery had finally come to fruition.

The Interim Army

Though the three-army model of today, tomorrow and the future formed the triad of land force development, the army transformation studies of 2001 and 2002 identified the requirement for the creation of an interim land force structure blueprint that provided a concrete description of what the Army would look like in roughly five years from the current structure. This "Interim Army" model served as a gap filler construct to link the existing current Army force structures to the Army of Tomorrow and became the benchmark for identifying the first tangible iteration of the Army of Tomorrow concept.

Major-General R.J. Hillier replaced Lieutenant-General Jeffery as commander of the Army in May 2003. Soon after entering office, he directed Brigadier-General H.M. Petras, the Director General Land Combat Development (DGLCD), to publish a companion to the Army strategy that described the force employment concept for the Interim Army model. The aim of the companion was to provide the Army commander with a much needed focal point from which he could energize army transformation as well as refer to when he asked the Chief of the Defence Staff (CDS) for resources to develop these new capabilities.[241]

Yet the simplicity of the direction belied the complexity of the challenge it presented. It was noted that although the existing force employment concept was detailed in the Army's various doctrine publications, it was not explicitly described in any one document. As one observer noted, "The concept itself permeates [across] the Army in unwritten form and through interpretation of doctrine and in practice." Still, nowhere could one find the concept articulated in a single document.[242] Furthermore, a series of organizational changes within the Army,

241 Email. LCol (ret'd) AG Morrow to Maj AB Godefroy, 16 October 2007.

242 DND, 1901-1 (DAD), "Seminar War Game Initiating Directive—Interim Army Force Employment Concept," dated 22 October 2003.

new operational demands as well as the introduction of new platforms and other equipment had all affected the existing army doctrine and concept of employment beyond what was currently codified. There was a growing concern that left unchecked without a clearly identified route, army combat development initiatives would become misguided as transformation progressed, doctrine would fall behind, and the Army's ability to reach its desired end state would become increasingly difficult if at all achievable.

To reach that desired end state, the Army first needed to understand exactly where it stood in its evolution. DGLCD directed that before the force employment concept could be written, a series of validation exercises and gap analyses were needed to truly understand what the current Army and its doctrine were capable of. Once this was determined in detail, then a force employment concept could be defined that effectively elucidated the role of the Interim Army within the context of the Army strategy. Finally, the gap analyses would reveal where further work was needed to bridge the Interim Army to the proposed concept for the Army of Tomorrow. Brigadier-General Petras assigned Colonel Fred Lewis, Director of Army Doctrine (DAD), to lead the gap analysis and force employment concept writing team, supported by DLSC and others as needed.

Early discussion papers and thought pieces on the Interim Army were produced by the DAD staffs over the summer of 2003, with the first substantial edited document prepared under the editorship of Lieutenant-Colonel Alan Morrow for wider release at the beginning of September.[243] Capability gap experiments and exercises were also conducted at this time to identify specific issues that might shape the context and content of the force employment concept as well as how it would link into the proposed Army of Tomorrow concept.

In late October, the Assistant Chief of the Land Staff (Asst CLS) was briefed on the work to date, and he provided further direction and guidance on the refinement of the original draft.[244] The senior leadership reinforced the need to follow a top down approach to army strategy development and directed that conceptual and doctrinal designs must employ an "ends, ways and means" process and rigour in its products. The Asst CLS also wanted to ensure that the term "joint" was clearly identified and defined within the context of the force employment concept. As the CF moved more towards a realization of both joint operations as well as growing interoperability with its allies, the issue of where the Army fit into the wider CF Strategic Operating Concept had to be clearly stated.

The first complete draft of the Interim Army force employment concept was delivered the day before Halloween 2003 tentatively titled "The Interim Army—A Force of Reckoning." Arguably not the pithiest title for a capstone document, it nevertheless conveyed a sense of the perception of the Army the DLSC and DAD staffs wanted to portray in the force employment concept. Yet it was Lieutenant-Colonel Brad Boswell, then Deputy Director of Army Doctrine, who coined the title that would later identify the publication. "I came up with 'Purpose Defined,'" noted LCol Boswell, "because we saw it as the next step to the army strategy which was named 'Advancing with Purpose.' As a companion to that document which would lay it out for the Army, it just made sense to give it a common look and feel."[245]

243 DAD, "The Interim Army—A Force Employment Discussion Paper," anonymous, dated 2 September 2003.

244 DLSC internal email, dated 23 October 2003.

245 Interview with LCol B Boswell, CFB Kingston, 10 October, 2007.

The DLSC and DAD staffs continued to move quickly on their task. Force planning scenarios that affected current doctrine and force structures were reviewed in early November 2003 with a view to finalizing the context in which the Interim Army force employment concept writing board would convene at the beginning of December. Using the operational functions as guidelines, detailed questions were asked and answers developed, which were then organized into one of three main groupings that guided writing development. The groupings were the context in which the Army existed and evolved, how it would fight and conclusions that shaped the way ahead to the Army of Tomorrow.

The Canadian Army's seventh Strategic Planning Session (SPS) was held in Kingston between 28 November and 1 December, 2003. Lieutenant-General Rick Hillier presided over the event and briefed the proposed Interim Army Model and Army of Tomorrow concept to the land force senior leadership.

A working draft document was completed by DLSC on 19 December, 2003 and then passed to DAD for further development. On 9 January, 2004, the first official draft of the Interim Army force employment concept was completed. This draft was circulated for review and comment to various directorates, offices, commands and schools across the Army. Comments and suggestions received back were worked into the draft.

On 1 February, 2004, a final draft was circulated for formal comment by senior Army leadership. With the last comments returned, a final draft was prepared for CLS approval at the end of the month. The document was approved, and the Interim Army force employment concept was published in companion form to the Army strategy on 31 March, 2004. Its release set the stage for the ongoing development of current army doctrine, expected to begin appearing in 2005.

Accordingly, given the commander's intent as laid out in *Advancing With Purpose* as well as the likelihood of responding to complex operations in the near future, the Army began to transform some of its organizations towards a command-centric, knowledge-based, medium-weight[246] infrastructure that was capable of applying the five operational functions of Command, Sense, Act, Shield and Sustain across the entire spectrum of conflict. This transformation also coincided with a CF wide transformation initiative beginning in early 2005. With these two changing paradigms, the Army began detailed experimentation of its proposed force employment concept for the Army of Tomorrow circa 2015-2020. The results of these experiments informed both the conceivers and the designers then working on the Army Futures Project at DLSC.

The Army Futures Project (AFP)

The Army Futures Project actually began shortly after the release of the new Army strategy in 2002. With the strategy published, the aim of the AFP was to complete the conceptual design of the Army of Tomorrow that would evolve out of the Interim Army model. An undoubtedly complex task, the first objective for DLSC was the completion of a comprehensive

246 Again, the Army Strategy describes *medium-weight* as the exploitation of emerging technologies to achieve the high levels of lethality and protection formerly provided by weight in order to enhance strategic responsiveness and operational and tactical agility. A medium-weight force balances the strong combat power characteristics of a more heavy-weight force with the strong, rapid deployability characteristics of a more light-weight force.

and well-thought-out context in which the Army of Tomorrow would exist as well as the list of potential capabilities that would be required to successfully operate in that environment.

These objectives were completed in early 2003 and subsequently published as *Future Force: Concepts for Future Army Capabilities*. A speculative thought piece presenting a conceptual framework designed to assist the Army leadership and those staff working on the Army of Tomorrow constructs, *Future Force* was the base from which further work developed. Overall it was a remarkably successful publication and was widely endorsed by the land force. Even allied armies commented on the value of *Future Force*: in addition to the many copies of the book requested by the United States, the United Kingdom and Australia, the presence of copies of *Future Force* was a regular feature at ABCA meetings.

Still, *Future Force* raised nearly as many questions as it answered. What would the world and the Canadian Army look like circa 2025? How would it operate in the proposed future security environment? These questions could only be further elucidated through examples. Therefore, employing a traditional Canadian Army method, the fictional narrative, a companion to *Future Force* was published in 2005. Titled, *Crisis in Zefra*, this fictional narrative served as an illustrative tool for the further exploration of many of the concepts first examined in *Future Force*. It presented one plausible future scenario for the Army of Tomorrow as well as a number of questions designed to encourage further debate across all ranks of the Army.

Figure 3-3: Capability Development Yesterday and Tomorrow

Corps 86 *Eight years to develop* *(1976-1984)*	*Land Operations 2021* *Two years to develop* *(2004-2006)*
• Well defined strategic context (Cold War)	• Poorly defined strategic context (Global War on Terror)
• Static theatre of operations	• Multiple theatre of operations
• Single spectrum operation	• Full spectrum engagement
• Well defined adversary	• Elusive and changing adversary
• Technologically predictable enemy	• Technologically innovative enemy
• Structured enemy forces	• Networked enemy forces
• Corps construct	• Battlegroup construct
• Rigid and concentrated forces	• Adaptive and dispersed forces
• Long term evolution cycle	• Very short term evolution cycle
• Limited third party considerations	• Crowded JIMP environment
• Controlled infosphere	• Uncontrollable infosphere

With the security environment and the roadmap in place, DLSC began work on the production of a new force employment concept that would connect the Interim Army to the proposed Army of Tomorrow. After completing a review and options analysis of the existing capability requirements developed in 2003, a series of hypotheses and questions were developed, examined and analyzed during a series of workshops and working groups from late 2005

through to the summer of 2006. In September, a seminar war game was held, which included representatives from across the military (including members recently returned from operational deployments at all rank levels), other government departments, non-governmental organizations (NGOs) and academics and scholars. This war game was followed by a series of army experiments late in the year, which returned the final analysis data to the DLSC team working on the new force employment concept.

In the spring of 2007, final drafts of *Land Operations 2021: The Force Employment Concept for the Army of Tomorrow* were briefed to the CLS, as well as a number of related organizations both inside and outside of the Army, to ensure that links to joint as well as interagency, multinational and public organizations were properly identified and encouraged. With consensus achieved on the way ahead, the CLS signed the new FEC into effect on 31 March, 2007. Within the greater context of CF transformation and a rapidly changing security environment, the Army had successfully transitioned from a Cold War conceptual and doctrinal design to one prepared to face the challenges of the current environment as well as those emerging on the horizon.

Part 2
Conceptual Frameworks

Chapter 4

Toward a JIMP—Capable Land Force

By Mr. Peter Gizewski and Lieutenant-Colonel Mike Rostek

> *"(T)he CF have to think and operate as a single entity, with air, land and naval assets working as a joint team, both at home and abroad. They have to learn how to work even more closely with all of the elements that can help in achieving the Canadian government's objectives, as well as those of whatever international coalition we may choose to work with…This implies changes to the command and control mechanisms, to the way the CF equips and trains its teams, and even in the way they are educated and view the profession of arms within the larger political and social context in which they will have operate, both at home and overseas."* —Lieutenant-General Andrew Leslie, Chief of the Land Staff[247]

In today's security environment, successful military operations are unlikely to be achieved through the use of military power alone. In a world where conflict often involves a myriad of ethnic, religious, ideological and material drivers, an ability to bring to bear all instruments of national, and coalition, power and influence (e.g., diplomatic, economic, military, informational) on a problem in an effective, coordinated fashion is increasingly essential to achieving effective results. So too is an ability to address and, if possible, effectively harness the views and reactions of the public, both domestic and international, as well as the media as operations unfold.

Canadian Forces (CF) acknowledgement of the need for a more coordinated and holistic approach to operations is ever more evident and pressing. Accordingly, DND leadership, both civilian and military,[248] have increasingly called for the adoption of a force that is joint, interagency, multinational and public (JIMP)-enabled. Such a force would see diplomatic, defence, development and commercial resources, aligned with those of numerous other agencies, coordinated through an integrated campaign plan and applied in areas of operations as needed. As such, the approach would see traditional and non-traditional military activities

247 Major-General Andrew Leslie, "Boots on the Ground: Thoughts on the Future of the Canadian Forces," The 2004 Haycock Lecture, *Canadian Military Journal* Vol. 6, No. 1 (Spring 2005).

248 Department of National Defence interest in JIMP has been evident in early drafts of the Strategic Operating Concept. See, Department of National Defence, *Canadian Forces Strategic Operating Concept*, Draft 4.4, 21 May 2004, For CDS Review (Ottawa: Department of National Defence, 2004). See especially pp. 17–18. And the Canadian Forces Experimentation Centre lists JIMP in its glossary of terms. Nor is interest in such an approach confined only to Canada. In fact, similar calls have been echoed in NATO circles. Speaking at a NATO meeting in 2004, Dr. John Leggat, former Assistant Deputy Minister for Science and Technology, observed that "(t)he alliance has agreed to adopt a more holistic approach to defence and security that deals with a full range of potential missions spanning the spectrum of conflict from crisis prevention to humanitarian operations through to high intensity warfare. This reinforces the need for a concerted and coordinated political, military, civil and economic approach. The military forces of the Alliance will have to operate in a multilateral environment alongside forces of other countries in close cooperation and coordination with a wide array of organizations. Future military operations will be linked to other informational, economic, social, legal and diplomatic initiatives and will need to be implemented." See http://www.act.nato.int/multimedia/speeches/2004/110304keynoteleggatcde04.htm.

being carried out collaboratively within a broader context known as the "effects based approach to operations" (EBAO), [249]resulting in greater mission effectiveness.

Land force interest in such an approach is particularly strong. Indeed, the capacity to be "JIMP-capable" or "JIMP-compliant" is now cited as an important enabler for the Army of Tomorrow (AoT) operating concept of adaptive dispersed operations (ADO)[250] and a key means to better ensure mission success in an ever-more-complex land environment.

Yet what precisely does it mean to be JIMP-capable? Why is this important in today's security environment? And how can such a capability be achieved?

The following discussion explores the opportunities and challenges that attend land force movement toward such an approach. More specifically, this discussion (1) examines the meaning of JIMP and the rationale underlying movement toward a more JIMP-capable Army, (2) the challenges and opportunities it presents, and (3) the requirements that must be addressed to ensure its effectiveness. The discussion concludes by identifying a number of initiatives and actions that promise to facilitate movement toward a more JIMP-enabled land force.

"JIMP-Capable" Definition, Rationale and Requirements

Definition

In essence, the term joint, interagency, multinational and public (JIMP) is a descriptor that identifies the various categories of players (i.e., organizations) that inhabit the broad environment in which military operations take place. To be "JIMP-capable" entails the adoption of an approach to operations, both domestic and international, that allows such players to effectively interact. Most importantly, it involves a belief in the requirement to adopt a comprehensive approach to problem solving that involves the holistic consideration and, ideally, the coordination of all relevant players.

A JIMP-capable organization involves *both* the development of a framework identifying key players and capabilities allowing for effective collaboration with those identified. Indeed, a JIMP-capable force would interact with players in four domains:

- **Joint**[251]—involving other national military elements and support organizations.

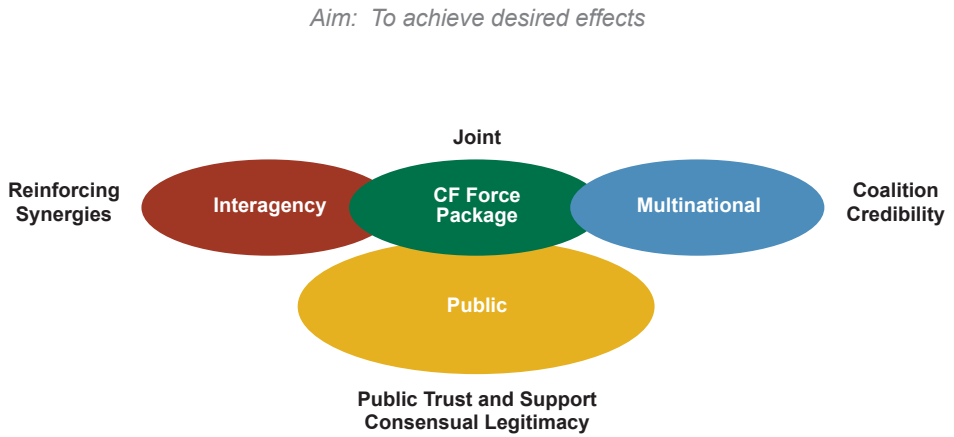
249 As defined by Edward R. Smith, effects based operations (EBO) are coordinated sets of actions aimed at shaping the behavior of intended targets (e.g., friends, allies, neutrals and foes in peace, crisis and war). See Smith, *Effects Based Operations: Applying Network Centric Warfare in Peace, Crisis and War*, DoD Command and Control Research Program (Washington, DC: July, 2003), p. 108.

250 See Directorate of Land Concepts and Doctrine, T*oward Adaptive Dispersed Operations, The Army of Tomorrow: Seminar Wargame Handbook*, 28 August to 1 September 2006 (Kingston: DLCD, Futures Cell, 2006), especially pp. 102–104; Director General Land Capability Development, *Proceedings of the Army of Tomorrow Seminar Wargame*, 28 August to 1 September 2006 (Kingston: DLCD, September 2006), especially pp. 10–11, 14–15, 18–19 and p. 22; and Directorate of Land Concepts and Doctrine, *Land Operations 2015: The Force Employment Concept for the Army of Tomorrow, Towards Adaptive Dispersed Operations* (Kingston: DLCD, 2007).

251 Adjective used to describe activities, operations and organizations in which more than one service of the same nation participates. Defence Terminology Bank, available at http://terminology.mil.ca/TermBaseWeb/Main2.aspx?changeTermbase=0.

- **Interagency**—involving other government departments (OGDs) and agencies (OGAs), both domestic and foreign (these agencies will include host nation government departments, including security forces, government departments and agencies from support nations and international government bodies such as UN agencies).
- **Multinational**[252]—involving one or more allies or international coalition partners.
- **Public**—involving a variety of elements, including domestic and international publics (including host nation populations, media agencies, non-governmental organizations [NGOs], public volunteer organizations [PVOs], international organizations and commercial interests involved in reconstruction and/or development programs and private security firms recruited to support the government).

Figure 4-1: Joint Interagency Multinational Public (JIMP)



CF operations must be viewed in a JIMP context, where a CF force package operates with multinational and interagency partners to attain unity of purpose and effort in achieving desired effects, all while considering the requirement for public trust and support, both domestically and internationally. Public consent will confer legitimacy to the operation.

Source: Department of National Defence, Canadian Forces Strategic Operating Concept, Draft 4.4, 21 May 2004, For CDS Review (Ottawa: Department of National Defence, 2004), pp. 17–18.

Yet a JIMP—capable organization *is also* informed by a willingness to *actively* engage other players in each of these categories in a collaborative and ideally cooperative relationship in pursuit of a desired end-state. And it requires that an organization has an awareness of the potential impact that its actions have on other players and on the likelihood of achieving

252 Adjective used to describe activities, operations and organizations in which elements of more than one nation participate. An adjective that connotes activities, operations, organizations, etc, between two or more forces or agencies of two or more allies. Defence Terminology Bank, available at http://terminology.mil.ca/TermBaseWeb/Main2.aspx?changeTermbase=0.

strategic objectives.[253] Indeed, what differentiates the broad JIMP environment from those interacting in a JIMP framework is *the reasonable expectation of co-operation* in a unity of purpose to achieve defined goals.

The JIMP construct is thus somewhat reflective of the "whole of government" and 3D+C (defence, diplomacy, development and commerce) philosophies articulated and advanced at the national level in recent international and defence policy statements.[254] In fact, JIMP more clearly specifies many of the categories of players that those policy statements describe. And becoming JIMP-enabled involves developing a capacity to interact with those in each category in a cooperative, constructive manner.

Rationale

Canadian Forces (CF) interest in JIMP and, more specifically, the capacity to be JIMP-capable thus reflects a growing belief in the importance of achieving greater interoperability and collaboration among key players in the operational arena as well as in the development of the requisite networking capabilities and skills increasingly essential to achieving one's objectives.[255]

Yet even more fundamentally, support for the creation of JIMP-capability stems from a growing consensus that outward focused, integrated and multidisciplinary approaches to security threats and challenges must be the norm to address the complex problems and challenges posed by an increasingly multidimensional security environment. That environment is increasingly dynamic, uncertain and challenging.

Often, it involves irregular and asymmetric conflict conducted by range of foes, including highly adaptive, media-savvy terrorist organizations intent less on physically defeating and

253 The authors are grateful to Mr. Georges Bordet of CANADEM for identifying and highlighting this point.

254 Both the 3D+C and "whole of government" philosophies derive from a broader interest on the part of government officials in a more collaborative, integrated approach to operations. As stated in Canada's most recent Defence Policy Statement (DPS), such thinking reflects the belief that "(a)chieving responsibilities and goals" in today's complex security environment will require, more than ever, a "whole of government approach" to international missions, bringing together military and civilian resources in a focused and coherent fashion. As part of this strategy, and building on recent experience gained in Afghanistan and elsewhere, the Department of National Defence and the Canadian Forces will work more closely with other government departments and agencies, including Foreign Affairs and the Canadian International Development Agency, to further develop the integrated "3D (+C) approach (defence, diplomacy, development and commerce) to complex conflict and post-conflict situations." See, *Government of Canada, Canada's International Policy Statement: A Role of Pride and Influence in the World Defence* (Ottawa: 2005), p. 28. Similarly, Canada's recent international policy statement notes that "…government Departments must become better connected with each other, and the system as a whole more efficient at leveraging current assets—wherever they reside." See *Ibid*., p. 26. Notably, one seeming distinction between JIMP and these other philosophies is that while the former aims at developing a capacity applicable to all operations, both at home and abroad, 3D+C and "whole of government" thinking tend be heavily international in both focus and intent (a fact at least implied by their inclusion of diplomacy and development as key aspects of their approach).

255 The Canadian Forces Experimentation Centre notes that joint, interagency, multinational and public. Command and Control concepts of specific interest will directly relate to interoperability issues associated with operations within the JIMP framework. Interoperability across JIMP categories will occur in three broad domains: information interoperability (the way we share information, including technological and procedural aspects); cognitive interoperability (the way we perceive and think reflected in doctrine and decision processes); and behavioral interoperability (the way we carry out the selected course of action). See Canadian Forces Experimentation Centre Glossary of Terms Website, available at http://www.ops.forces.gc.ca/cfec/viewHTML_e.asp?islandid=452).

destroying armed forces than eroding their will to fight, warlords seeking to retain power and influence over local populations at any price, and trans-national criminal organizations ready, willing and able to buy, sell and trade everything from drugs to armaments for their own gain. Often as well, the security environment involves failed and failing states, whose tenuous existence and inability to meet popular demands offer ready breeding grounds for rebellion and civil war and a secure base from which adversaries can function. And, it involves complex human and physical terrain, with large, densely populated cities and highly diverse (ethnically, religiously, economically and culturally) populations often serving as the backdrop for military operations.

Increasingly, conflict zones are highly fluid and multidimensional. Battle lines often have no clearly defined boundaries. Enemies are often dispersed over a wide geographical area. And, distinguishing friend from foe or neutral is difficult. Beyond this, conflict itself represents only part of the problem, as rampant civil disorder, famine and disease linger in the background and threaten societal collapse as well as the prospect of even more carnage to come. As such, efforts to address these dangers may well be as crucial to military success and the creation of stability as prevailing on the battlefield. In fact, future conflict is likely to be as much about gaining trust and legitimacy among surrounding populations as engaging in armed combat and destroying adversaries.

The upshot of such a world is greater complexity, both in terms of the causes of instability and the solutions required to address it. It also suggests that dealing with future challenges may well involve a wider range of personnel, skill-sets and resources than ever before. To be sure, traditional reliance on military power will often provide one component of the solutions required. Yet the prospective role(s) and the relative importance of the military and of other organizations in providing lasting solutions will nonetheless vary, both from case to case as well as within each case that arises. So also will the need of such organizations to interact, cooperate and collaborate with a range of players if solutions pursued are to be effective and lasting.

The JIMP concept reflects an implicit recognition of the CF's need to address such realities. In fact, it is critical in order to balance the requirement to be able to fight and win in war—the CF's fundamental role—with the need also to be able to undertake a wide range of operations other than war (OOTW).

By attempting to better enable collaboration and cooperation between the military and other, often non-military and non-governmental, organizations and interests, JIMP promises to increase the likelihood that the information skills and resources needed to address the problems and challenges that the complex security environment raises will be available and effectively brought to bear. Such interaction would promise to increase the quantity, quality and types of information available to commanders, thereby increasing situational awareness. It would help sensitize players to a variety of viewpoints and variables at work within an operation as well as a number of potential second- and third-order effects which their actions may yield. And, it would help to better ensure that the actions of the military as well as those of other players are better coordinated in support of broader mission goals and objectives. Indeed, such interaction promises to make decisions and actions more strategic in character.

Most importantly, a JIMP capability could serve, over time, to better socialize both the military and other organizations within the JIMP environment to the varied demands of the security environment itself and the important contributions which each can, and should, make in addressing its challenges. The result would be a clearer understanding, respect and appreciation of the assets which varied players bring to the table in addressing security challenges, a willingness to cooperate with these players if and when possible and to defer to others in reaching such goals when circumstances warrant. In short, a JIMP capability would serve to generate a more "holistic" view of security and how to achieve it.

Requirements

To be sure, realizing such an integrated, holistic approach to operations is challenging. For the military alone, the demands that realization of a JIMP-capability would involve are numerous, with the initiatives required likely to include:

- The adoption of a team approach to develop an integrated campaign plan in order to realize its operational objectives in full spectrum operations.
- Creation of an ability to immediately plug into joint battle space operating systems to interoperate effectively.
- The capacity to access key information in an efficient timely manner so as to identify targets for attack and influence as well as determine JIMP resources required in operations.
- The willingness to consider second- and third-order effects in its planning process.
- An ability to facilitate the building of interagency and multinational interoperability through collaborative planning mechanisms and protocols.
- An ability to connect non-governmental agencies with CF operational architecture and provide liaison to support these agencies in the execution of the mission.
- The ability to communicate with joint and other multinational agencies. (This also would include the ability to provide an efficient interface between conventional and special forces.)
- An ability to clearly and effectively communicate mission goals, objectives and actions to the public and members of the media as required.

Add to this, the diversity of organizations and agencies that inhabit the JIMP environment—each with its own culture, mindset, biases and capabilities, along with the need to connect with publics in a clear, constructive manner—and the challenge of devising a truly effective JIMP approach to operations is doubly challenging. The fact that the effectiveness and credibility of some organizations, particularly certain NGOs, can be seriously compromised if they are perceived as working with military organizations only compounds problems.

Such dilemmas suggest that establishing goals for the development of an effective JIMP capability must be measured and realistic. In particular, they must be based on a recognition that the involvement of certain organizations and players within the JIMP environment can

and will vary. So too will the character and quality of the relationships and interactions that ultimately occur. In fact, possession of JIMP capabilities by military organizations cannot, in and of themselves, guarantee that an effective JIMP approach will always be followed (result). Rather, both the capability and willingness of other organizations and players to engage in a cooperative relationship is essential. And that, in turn, will often be somewhat dependent on the character of the players involved as well as their own resources, agendas and goals.

Still, the creation of a JIMP capability can help to increase prospects that such interactions not only occur but that they are also cooperative, constructive and useful, not only to the military but to all those involved. Indeed, while the creation of a JIMP-capable organization cannot bring all players to the table, it can at least ensure that the option to link is present for those willing to participate and that the linkages and interactions that occur are as effective and valuable as possible. Beyond this, a JIMP-capable organization can increase prospects that all concerns of JIMP participants are considered and addressed in the CF decision-making process.

Efforts at Implementation

Certainly, CF and land force interest in a JIMP approach is not without precedent. In fact, efforts to practice a more JIMP-oriented approach to operations are currently underway. Ongoing operations in Afghanistan offer a case in point. Over the course of Western involvement, coalition allies have combined counterinsurgency operations involving Special Forces and regular infantry with broader efforts aimed at stabilization and reconstruction of the country. Military, diplomatic, development and law enforcement personnel are working together in a relatively collaborative, cooperative framework to help realize the Afghanistan National Development Strategy (ANDS) and thus bring stability, prosperity and good governance to the country.[256]

Within this context, new forms of military organization such as provincial reconstruction teams (PRTs) have emerged and are undertaking stability and reconstruction tasks. First established in early 2003, PRTs consisted of 60 to 100 soldiers plus, eventually, Afghan advisors and representatives from agencies such as foreign affairs and international aid and development agencies. PRTs have the potential to become a model for future stabilization and reconstruction efforts.[257]

Today, there exist approximately 24 PRTs from 13 countries operating in Afghanistan. They have played important roles in everything from election support to school-building to disarmament and mediating factional conflicts.[258] Although PRTs are not without their problems, including inconsistent mission statements, unclear roles and responsibilities and ad hoc preparation, PRTs provide a good starting point for developing tools to achieve JIMP success in future security missions.

256 Here, while success is by no means assured, the experience of "learning by doing" is likely to prove beneficial for the conduct of future operations, offering lessons for future consideration. Already, for instance, it has underlined the benefits of an integrated approach, making clear that the presence of HUMINT and civil affairs, as well as an effective information campaign, is critical to achieving success in stability phase of operations.

257 Michael J. McNerney, "Stabilization and Reconstruction in Afghanistan: Are PRTs a Model or a Muddle?" *Parameters*, Winter 2005-06, pg. 32.

258 Michael J. McNerney, "Stabilization and Reconstruction in Afghanistan: Are PRTs a Model or a Muddle?" *Parameters*, Winter 2005-06, pg. 33.

The Disaster Assistance Response Team (DART) also assumes a range of tasks that encompass JIMP contributors. Formed in 1996 after the Canadian government recognized the need for a rapid response capability to provide effective humanitarian aid, DART extends the CF's warfighting training regime[259] by tasking it to provide humanitarian assistance in response to both natural disasters and complex humanitarian emergencies. Today, the CF has about 200 personnel ready to deploy in forty-eight hours to any location in the world.

Such organizations are illustrative of nascent JIMP capability within the CF. Neither has a warfighting focus as a primary function.[260] And perceptions of their growing utility increasingly suggest that traditional understandings of warfighting as the dominant paradigm for armed forces is shifting as tasks once considered "sideshows" increasingly occupy "centre stage." That said, much more remains to be done if JIMP capabilities are to be firmly institutionalized. Indeed, a truly JIMP-capable force will require: the elaboration and eventual codification of JIMP procedures, protocols and standards of best practice, the creation of training and education programs for effective JIMP operations (including the possibility of training in the establishment of effective governance), some determination of the level at which JIMP activities are best integrated into operations (e.g., task force, battalion, etc.), an identification of the conditions which must be satisfied for operating with NGOs in the field and some idea of how best to develop effective communication strategies for dealing with the public and media as operations unfold.

Beyond this, the human and technological networks that an effective JIMP capability involves must be further elaborated, with initiatives to identify and inventory the individuals, organizations and agencies likely to be significant perhaps serving as an important first step in developing a truly capable and collaborative JIMP approach to security threats and challenges.[261]

Toward a JIMP-Capable Land Force

To be sure, JIMP is a broad concept and is beyond the sole purview of the land force. The CF as a whole represents but one JIMP player among many. However, it is within the land force, and especially its Army of Tomorrow (AoT) conceptual construct, that efforts to

259 The Canadian Army has adopted an operational model to better explain the different scenarios Canadian soldiers may face. "View 1" operations involve intense combat missions in situations of general war such as those in Korea or the Second World War. "View 2" operations involve a mix of combat and non-combat operations in conflicts that differ from traditional interstate warfare and include Rwanda and Sierra Leone. The overlap between the two is defined as the CF's "vital ground." The Canadian Army is frequently committed to View 2 operations while retaining its standing requirement to be prepared for View 1 eventualities. The prospect of combat is prevalent in both views. Furthermore, the effectiveness of forces engaged in View 2 missions often rests on their demonstrable ability to use combat power to achieve their goals, even if this combat capability is held as a deterrent. Therefore, a credible combat capability is seen to be essential for both views. Consequently, the Canadian Army trains its soldiers, leaders and units for View 1 multipurpose, warfighting skills and adds to this training the theatre and mission-specific training required for View 2 operations. Canada, National Defence, Chief of the Land Staff, B-GL-300-008/FP-001, *Training Canada's Army*, 2001-08-30, pg., 14.

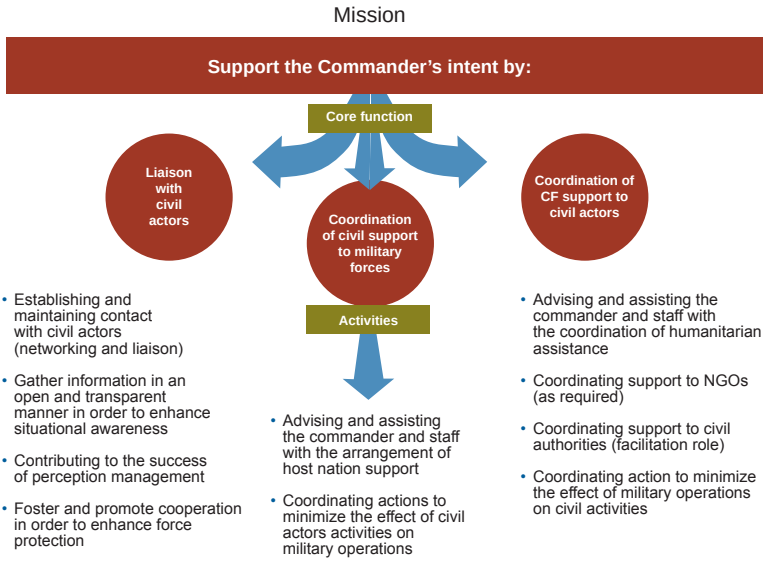
260 Indeed, while the PRT does have a definite "use of force" requirement in non-permissive environments, its broader economic, environmental, human and societal aspects are nonetheless clear and far more predominant.

261 Based on these requirements, Land Futures convened a working group to investigate many of these questions. The following section outlines work to date on the JIMP line of investigation undertaken in support of the AoT Force Employment Concept.

operationalize JIMP have received particularly detailed attention and expression. Indeed, Land Futures of the Directorate of Land Concepts and Doctrine (DLCD) has recognized the importance of JIMP as an enabling concept[262] both for the CF and the land force. And initial analysis clearly suggests grounds for optimism.

In fact, when broken down into its component parts, it is clear that the ideas underpinning JIMP are not particularly novel. The joint and multinational aspects of JIMP are already well established, both within the Continental General Staff System and in the Canadian practice of staff responsibilities.[263] And while the interagency and public components pose greater challenges for the land force—most notably in terms of interfacing with entities that are essentially non-military in nature and have well-established cultures—some experience is nonetheless resident in past civil-military cooperation (CIMIC) practice.[264] Ever since the creation of civil affairs units, CIMIC has been considered a force multiplier[265] for commanders, increasing prospects for accessing crucial information on local conditions and threats and thereby working to improve decision-making on the effective use of military resources. CIMIC, a wholly reserve function within the land force, provides an institutionalized foundation from which the JIMP concept, in particular the interagency and public components, can evolve (see Figure 4-2).

Figure 4-2: Civil-military cooperation core functions and activities



262 An enabling concept is a description of how a particular task or procedure will be performed, within the context of a broader functional area using a particular capability, such as a specific technology, training or education program, organization, facility, etc. An enabling concept describes the accomplishment of a particular task that makes possible the performance of a broader military function or sub-function.

263 Department of National Defence, B-GL-300-003/FP-000 *Land Force—Command*, 1996, pg. 70.

264 For a complete review of CIMIC doctrine, see B-GL-355-001/FP-001 *Civil-Military Cooperation Tactics, Techniques and Procedures*, 2006.

265 A force multiplier is a military term referring to a factor that dramatically increases (hence, "multiplies") the combat-effectiveness of a given military force.

Source: Canada, National Defence, Chief of the Land Staff, B-GL-355-001/FP-001 Civil-Military Cooperation Tactics, Techniques and Procedures, 2006-03-01, pg. 4.

With the foundations for JIMP already in place (the Continental Staff System and CIMIC), further development of JIMP as an enabling concept can proceed. Within the land force, this is undertaken through the Land Force Capability Development Process.[266] Research performed to establish the foundation and conditions for future work is articulated through a PRICIE[267] analysis, which provides a structured approach to identifying new land force capabilities and/or deficiencies and provides a process to design conceptual structures. In terms of the JIMP concept, a "conceive" PRICIE analysis yields a number of insights in a range of key categories.

Personnel, Leadership and Individual Training

Personnel. As noted by Christopher Ankersen, "…human capital is a key component in developing defence capability."[268] This point has not gone unnoticed by the Land Futures staff in the development of a JIMP capable AoT. However, although one would immediately assume that military personnel are the sole focus of the JIMP concept, this has not been the case. Land forces are more familiar with the joint and multinational components than with the interagency and public components, and there has been clear recognition that the interagency and public components of JIMP cut across many cultures and organizations. Although there is no tolerance for military parochial viewpoints in the development of a JIMP concept, it is understood that there is little the CF can do to prevent parochial positions from other JIMP contributors. What is important to recognize at this point is that within the emerging security environment, status quo attitudes that reflect the total subordination of other JIMP contributors, in particular interagency and public, to the defence agenda will not suffice. This is not to degrade or downplay the importance of the security function within that environment but rather to recognize that in conflict zones of the future, there will be many more players, inside and outside Canada's "whole of government" approach, whose agendas may not necessarily coincide with that of the military.[269]

The land force personnel who best represent the JIMP capability at present, especially the interagency and public components, are those within the CIMIC specialty.[270] The fact that the reserves singularly execute this function within the land force has not gone unnoticed. There is both promise (broad mix of civilian capabilities) and peril (sustainment of operations)

266 The methodology and procedure is detailed in the Army Strategic Decision Making Handbook (ASDMH). For the history of capability development within the CF, see Major Andrew B. Godefroy, PhD, "Chasing the Silver Bullet: The Evolution of Capability Development in the Canadian Army", *Canadian Military Journal*, forthcoming.

267 PRICIE—Personnel, leadership and individual training; Research & development / operational research (plus experimentation); Infrastructure and organization; Concepts, doctrine and collective training; Information management; and Equipment and support.

268 Christopher Ankersen, "The Personnel Crisis," *Canada without Armed Forces*, Douglas Bland ed., (Kingston: School of Policy Studies, 2003), pg. 35.

269 The increase in the use of private military contractors (PMCs) has grown dramatically these last ten years. During the first Gulf War in 1991, for every one contractor there were 50 military personnel involved. In the 2003 conflict, the ratio was 1 to 10. Deborah Avant, "The Privatization of Security and Change in the Control of Force," *International Studies Perspectives* (2004) 5, pp. 153–157.

270 For further development of CIMIC as reserve task, see David Peabody, "The Challenges of Doing Good Work: The Development of Canadian Forces CIMIC Capability and NGOs," October 2005, available at http://www.cda-cdai.ca/symposia/2005/Peabody.pdf.

associated with the reserves solely undertaking this function. However, current thinking within the CIMIC Directorate is a preference for full-time staff with little regard to whether the person is Reserve or Regular Force.[271] Historically, there has existed a cultural divide between the reserves and the Regular Force that continues to exist in various forms today. Much of this divide involves issues of trust. This has obvious implications with the reserves filling a function believed to be a key enabler in the emerging security environment. However, anecdotal evidence suggests that when the two forces are brought together for operations, the necessary levels of trust emerge between the commander and staff regardless of whether the soldier is Regular or Reserve Force.[272] The fact that the reserves have been able to fulfill this task is good news in light of the occupational shortfalls and challenges related to human resource planning and retention which the CF faces.[273] In fact, this issue supports a view expressed by some that the CF are not leveraging the reserves to their full capacity and that they may provide more cost-effective investments to increasing CF capacity.[274]

As noted above, human capital is the key to developing a JIMP capability within the land force. Although CIMIC informs the JIMP concept and represents the more difficult aspects—the interagency and public components—it does not wholly represent the JIMP capability, which is more holistic in nature as described above. However, the full-time CIMIC capability currently resident within the CF represents an institutionalized structure from which the CF can build a part of its JIMP capability. From an AoT perspective, the reserves offer the specialty roles and capabilities associated with civilian qualifications as well as some of the expertise relevant to establishing a more robust JIMP capability in the future operating environment.[275]

Leadership. Army leadership is fundamental to the development of force employment concepts.[276] The direction to conduct a separate line of investigation concerning a JIMP capability for the AoT signals recognition by Army leadership of the importance of this function within the emerging security environment. Furthermore, the pervasiveness of the JIMP concept anticipated in that context relates directly to the current Canadian government's "whole of government" approach and the CF's focus on the so-called three-block war. CF CIMIC policy highlights the importance of this capability in current operations.

In contemporary CF operations, civil-military relations have become increasingly complex, and the degree of interaction required between deployed forces and civil actors is now significant. Likewise, civil actors have a great impact upon the conduct and successful

271 JIMP Working Group, DLCD Kingston, 23 October 2006, LCol Rick Powell, Deputy Director CIMIC.

272 See "Canadian Army needs reservists to fill gaps: Commander", viewed 30 Nov 06 at http://www.cbc.ca/canada/story/2006/11/21/reservists-pressure.html, and "'No Worry' with reservists in combat", viewed 30 Nov 06 at http://www.hamiltonspectator.com/NASApp/cs/ContentServer?pagename=hamilto/Layout/Article.

273 See Ombudsman Report, *The Canadian Face Behind the Recruiting Targets: A Review of the Canadian Forces Recruiting System: From Attraction to Enrolment*, 19 Jul 06, viewed 24 Nov 06 at http://www.ombudsman.forces.gc.ca/reports/special/recruitment/recruit_toc_e.asp.

274 For further thoughts on this issue, see Michael A. Rostek, "Developing a Surge Capacity for the Canadian Forces," *Defence and Peace Economics*, Keith Hartley and John T. Warner, eds., Vol. 17, No. 5 (October 2006), pp. 421–434.

275 Directorate of Land Strategic Concepts, *Future Force: Concepts for Future Army Capabilities* (Kingston, Ontario: Army Publishing Office, 2003), pg. 205.

276 Ibid.

outcome of CF operations. As a result, effective coordination of information and activities between deployed forces and civil actors is now a key element to the success of CF operations.

Although civil-military cooperation has existed in military operations for many years, the conduct of modern military operations is constantly changing and evolving. As part of this change, it is now recognized that the civilian environment in which military operations take place must be considered in everything the CF does. A robust CIMIC capability is required to ensure that the intentions and actions of civil actors are coordinated with military intentions. This policy is intended to be the foundation for the development of the CF CIMIC function and capability.[277]

If we return to CIMIC as the institutional foundation for a JIMP capability, the importance of leadership may be articulated as follows:

CIMIC, whether domestic or international, is a command responsibility and requires leadership from the highest military appointments in cooperation with the heads of civilian agencies.[278]

As such, the successful implementation of a JIMP concept will require continued active endorsement from CF and Army leadership as well as OGDs.

Individual Training. Adaptive dispersed operations, the foundation of the AoT, demand that every soldier be a JIMP contributor. Today, we are witness to the genesis of this concept through the three-block war and "whole of government" approach. As such, it would be prudent for the Army and CF to address the pervasiveness of the JIMP concept for the AoT through an appropriate and effective regime of individual training. Reaching down to the individual level of training will provide the necessary foundation for the establishment of a JIMP capability. To a certain degree, it is understood that many of the JIMP concepts already exist within the current Army training system; however, it is recommended that the JIMP concept be driven down further, i.e., to the Basic Individual Training and Education level as outlined in DAOD 5031-2,[279] thereby highlighting its importance.

From a philosophical standpoint, there is considerable literature and research which concludes that soldiers, in response to what are called "new wars,[280]" are taking on greater non-warfighting functions (i.e., policing and development projects) that seem at odds with their traditional warfighting roles. Although it is not the intent to examine this debate here, it should be noted that this idea fits neatly within the three-block war construct as well as the recent development of a CF provincial reconstruction team and is perhaps an indication of things to come.

277 CF Policy on Civil-Military Cooperation (CIMIC), viewed 10 Nov 06 at http://sjs.mil.ca/dgplans/supportspec/pages/cimic_e.asp#policy.

278 National Defence, B-GG-005-004/AF-023, *Civil-Military Cooperation in Peace, Emergencies, Crisis and W*ar, 1999, viewed 10 Nov 06 at http://cfd.mil.ca/conceptsdoctrine/docs/AF-023_e.pdf: 1-1.

279 DAOD 5031-2 Individual Training and Education Management Framework, viewed 10 Nov 06 at http://www.admfincs.forces.gc.ca/admfincs/subjects/DAOD/5031/2_e.asp.

280 Mary Kaldor, *New and Old Wars: Organized Violence in a Global Era* (Stanford: Stanford University Press, 1999), pp. 1–2.

Research and Development (R&D) and Operational Research (OR)

Research and Development. Thrust Advisory Groups (TAGs) exist for each of the operational functions—Command, Sense, Act, Shield and Sustain. TAGs are well suited to address R&D issues surrounding a JIMP concept. For example, building trust between different cultures, be they within the CF, OGDs or NGOs, is a critical prerequisite for the emergence of an effective JIMP concept. This is in fact a Command TAG experiment being conducted at DRDC Toronto, which currently has a CF focus but has the potential for expansion to incorporate the broad range of JIMP contributors.

Operational Research. The significance of OR and its success in support of commanders is well documented. OR support to Army commanders extends as far back as Vimy Ridge (1917) and includes current operations in Afghanistan.[281] As such, it is anticipated that OR will support research focused on the JIMP concept. For example, Army Experiment 9A recently exercised, in part, the JIMP concept within a warfighting context. And examination of the JIMP concept in a peace support operation, a humanitarian crisis or in a disaster assistance response context, both international and domestic, is being considered for future Army experiments within a synthetic environment. Furthermore, consideration is being given to implementing an OR team within the AoT experimental battle group set to commence in the summer of 2007.

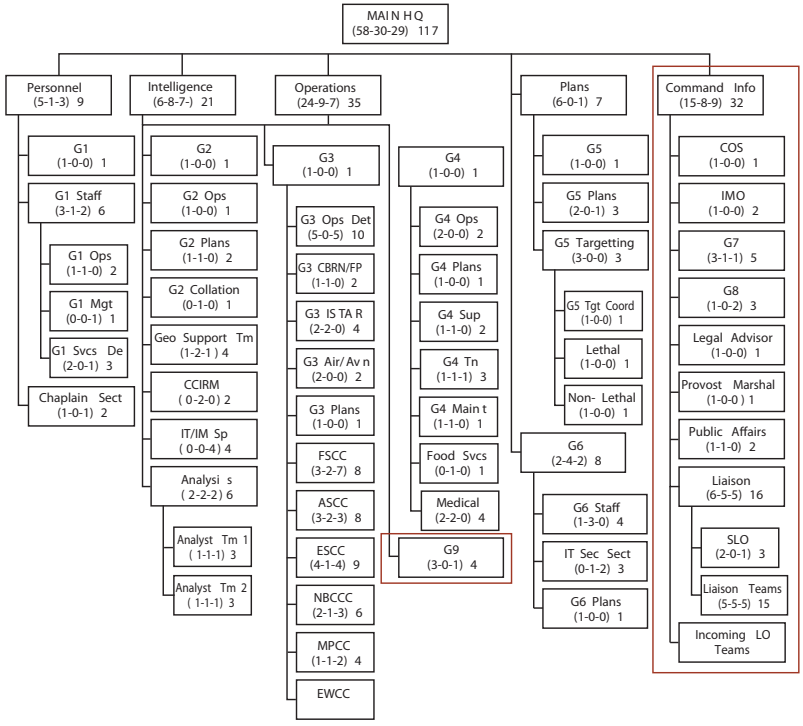
Infrastructure, Environment and Organization

The AoT construct does not envisage major infrastructure changes to further the JIMP concept. As mentioned earlier, the Continental Staff System and the CIMIC specialty provide the institutional foundations to build a JIMP capability. Viewed primarily as a holistic approach to operations, the chief focus of JIMP is on inculcating a new approach to operations primarily involving new agencies and publics while retaining and indeed improving joint and multinational collaboration and cooperation in both warfighting and stability and reconstruction operations. However, while it is anticipated that interagency and public organizations will become more closely integrated into a force structure, it is expected that they will be non-permanent structures. Furthermore, it is anticipated that liaison officers (LOs) in support of the JIMP concept (i.e., LOs to other agencies and publics) will become increasingly important and more numerous.[282] The increased importance of the JIMP capability and LOs can be viewed within the latest designs for current battle group and brigade headquarter structures (see Figures 4-3 and 4-4). Moving to a fully JIMP capable headquarters will constitute an evolutionary step from the structures illustrated below (permanent JIMP capabilities outlined in red with non-permanent in yellow box).

281 For a more detailed view, see Fred Cameron's "A Century of Operational Analysis for Commanders in the Canadian Army," viewed 10 Nov 06 at http://www.mors.org/meetings/combat_analyst/read_aheads/Cameron-SAS44-A_Century_of_OA.ppt.

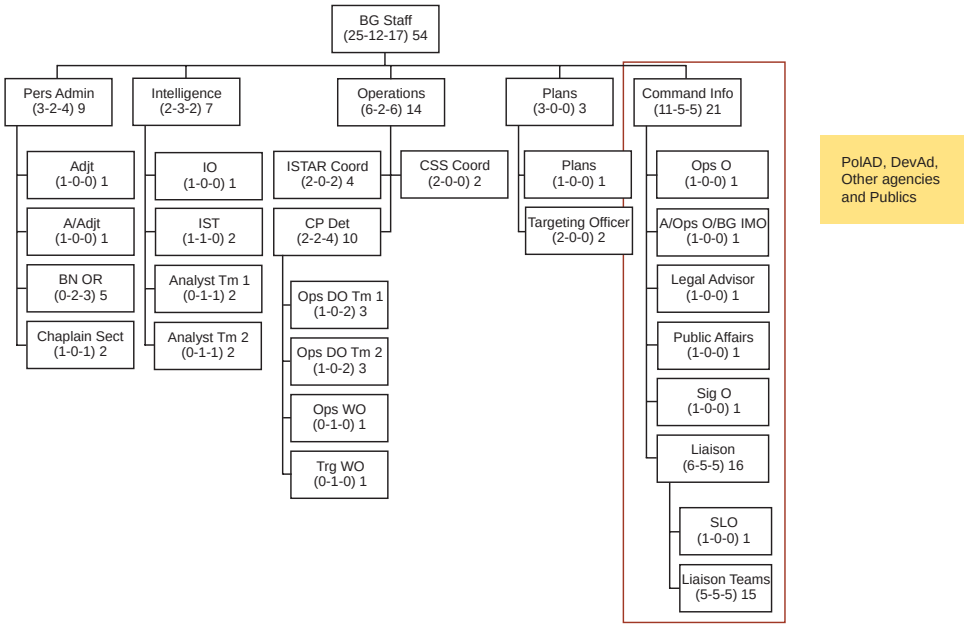
282 This fact is supported by proprietary research conducted at DRDC Toronto.

Figure 4-3: BDE and BG Structures



Source: Director Army Doctrine, *BDE and BG Structures 11 Oct 06*, viewed 17 Nov 2006 at http://lfdts.army.mil.ca/dglcd/files/03_CDR/03_CDR_Active/06004_Command/CDR.

Figure 4-4: BDE and BG Structures



Source: Director Army Doctrine, BDE and BG Structures, 11 Oct 06, viewed 17 Nov 2006 at http://lfdts.army.mil.ca/dglcd/files/03_CDR/03_CDR_Active/06004_Command/CDR.

Concepts, Doctrine and Collective Training

Concepts and Doctrine. As mentioned above, the JIMP concept is not entirely new to the CF. Joint and multinational aspects have been with us for some time and resident with the Continental Staff System. For future development, it is recommended that the Continental Staff System be retained to adequately represent the joint and multinational aspects of the JIMP concept.

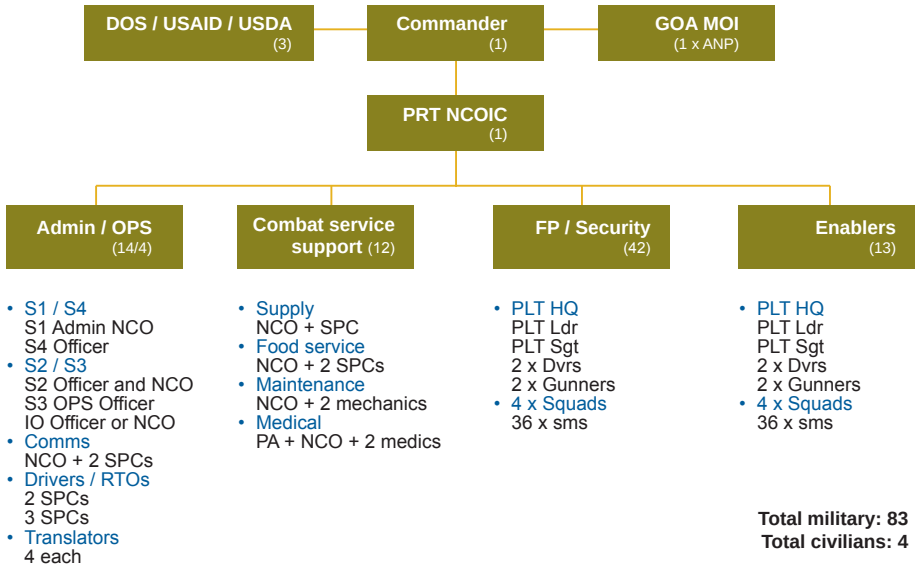
Interagency and public aspects of the JIMP concept have been evident within CIMIC doctrine. The real change, however, is the increased emphasis of the interagency and public aspects in the contemporary operating environment and the future security environment. Here, while our current tactical CIMIC doctrine is sound, the operational level requires revision. In fact, such revision may provide the backbone for future JIMP concept doctrine development.

Provincial Reconstruction Teams (PRTs). PRTs[283] inform the JIMP concept, as they bring together the military (including CIMIC), agencies and publics under a single construct in a conflict zone. Although there are many lessons which still must be learned from this new type of unit, the PRT can been seen as representative of the next iterative step for both brigade and battle group structures incorporating political, developmental and other JIMP players (RCMP, Corrections Canada, NGOs, etc.) on a permanent or non-permanent basis.

283 For more information on Canada's PRT, visit http://www.canada-afghanistan.gc.ca/prov_reconstruction-en.asp.

Although the core PRT structure illustrated below is a US model, it highlights the interagency and publics perspectives of the JIMP concept (outlined in red) and their position within the unit.

Figure 4-5: PRT Core Task Organization



Source: US Aid, *Provincial Reconstruction Teams in Afghanistan: An Interagency Assessment*, viewed 17 Nov 2006 at http://pdf.usaid.gov/pdf_docs/PNADG252.pdf: 28.

Collective Training. The required pervasiveness of the JIMP concept throughout the CF is important and can be achieved to a certain degree through individual training and education initiatives specifically aimed at highlighting its significance for the current Army and the AoT. However, higher-level formation and general staff training must be achieved through collective training. Collective training must incorporate OGDs, international organizations (IOs), NGOs and private voluntary organizations (PVOs) to inculcate coordination aspects of the JIMP concept such as collaborative planning. An ability to integrate the above agencies into the operational architecture and provide liaison to support them is crucial for JIMP success.

Information Management and Information Technology

Information management and information technology will be a crucial aspect of a JIMP-enabled HQ. Security protocols resident within the CF as well as other agencies will require careful study to enable an adequate functioning of the JIMP concept (e.g., access to key information). An immediate “plug and play” capability in the JIMP environment will be required to interoperate quickly and effectively. And all agencies will require communications utilizing the latest technological advancements.

Equipment and Support

At this time, it is anticipated that the major capital requirement to support a JIMP concept will reside within the information management and information technology realms, namely communications equipment and other network hardware.

Conclusion

JIMP is a concept that will have a considerable impact within the emerging security environment. Although primarily holistic in nature, JIMP articulates a perspective of operations which until recently has been regarded as being of secondary importance to the military. Yet times are changing. In parallel with the US's declaration that conventional warfighting operations and stability and reconstruction operations are equally "decisive,"[284] the Canadian government has endorsed "whole of government" and 3D+C philosophies, whereby the security mission is no longer the sole purview of military forces. The nature of operations today and in the future will resemble the three-block war construct, a construct which demands that soldiers interact with many different players other than their own armed forces and undertake non-traditional tasks. This is in fact a new norm for the Army. It is also a norm that reflects the dynamics of the current and future security environments.

Although there remain many issues to be researched and discussed with respect to a JIMP-capable Army, three broad areas demand particular attention:

Security. A JIMP-capable army does not imply an abrogation of its security function. Rather, it implies a recognition that the future security environment is much more complex, with an increasingly varied number of players interacting within it. Indeed, a range of players can contribute to the security function. Furthermore, decisive operations do not equate exclusively with warfighting. Increasingly, stability and reconstruction tasks are of equal importance. It is perhaps the United States that has led the way in institutionalizing this concept. In fact, it is reflected in US Presidential Order No. 44 as well as in current US Army capstone doctrine. Within the Canadian Army, the evolution of the DART and PRT, along with recent recommended changes to battle group and brigade HQ structures (including CIMIC), provide the foundation from which a JIMP capability for the Army can be further developed and institutionalized.

Coordination and Networking. A JIMP-capable army requires a robust coordination and networking function. Although there is a general perception that the military will attempt to control the agenda through its robust communications infrastructure and coordination capabilities, this is simply not the case. Within the emerging security environment, there will be few organizations, if any, equipped as well as a military force to sponsor this critical function. As such, the Army must be equipped and trained to support a broad coordination and networking function with NGOs, IOs, OGDs, coalition forces and, potentially, host nation publics. The necessity of this function also highlights the importance of enabling concepts, such as the network, and of networking technology to support effective and robust communications with JIMP contributors.

Consequence Management. A JIMP-capable army will also be expected to conduct efficient consequence management. Although there is no official definition of this term, the AoT must

284 United States Government, Secretary of Defence presentation, viewed 3 Oct 06 at www.ndu.edu/ITEA/storage/687/Army%20Support%20to%20SSTR.

be ready to systematically take action in the face of life threatening or destructive events. As such, JIMP contributor roles, responsibilities and plans must be identified, and a clearly defined response channel set up. From battle damage to infrastructure destruction to the deaths of innocent bystanders, a JIMP-capable army must be ready to react alone or in concert with other JIMP contributors. A lack of ability in this domain will allow opposing forces to seize the initiative and exploit events to their own benefit.

To be sure, the creation of an effective and truly holistic JIMP capability will pose a range of challenges. Yet initiatives in the three broad areas outlined above are especially important. Only then will JIMP represent a truly effective means for coping with the increasingly complex challenges likely to characterize the security environment in the years ahead.

Chapter 5

The Army of Tomorrow Optimized Battlegroup Experiment

By Major Jim Terfry

As the 21st century unfolds, Canada continues to face an international arena marked by uncertainty, volatility and risk. While many threats have receded, others have grown in importance, and still others have arisen in their place. The threats we now face are complex and often asymmetrical in nature. It is within this uncertain context that the land force must continue to operate to meet Canada's national security needs and expectations. However, this entails an inherent requirement to do so not only in the short term but also in the long term. As such, the Army must work towards a fuller understanding of the character of the future security environment and its implications for armed conflict. Moreover, it must foster operational concepts and doctrine that are clear, relevant and always forward-looking. Finally, it must seek capabilities, such as optimized force structures, that ensure its effectiveness in the future battlespace at home and abroad.

To mitigate against the unpredictability of future conflict and prepare the Army for the challenges that it might face in the future, the Director General of Land Capability Development (DGLCD) was tasked to prepare a force employment concept for the Army of Tomorrow (AoT). This document, formally endorsed by the Chief of the Land Staff (CLS) in February 2007, will act as the guide for land force development through to 2021. It is ambitious and forward thinking but at the same time well grounded in the lessons that we have captured from today's operations. In essence, it is a conceptual guide, from which force generation must evolve, acknowledging where we are, what we have achieved, and what we must do to ensure continued success in the future. To that end, while not proposing any definite structure, it highlighted the need for any AoT organization to be modular to allow the land forces to become adaptive and remain robust, while providing the agility needed for rapid and sustained deployment of forces at home and abroad.

In October 2006, the DGLCD directed that three single-issue lines of investigation (LOI) be undertaken in advance of the formal endorsement of the *Land Operations 2021: The Force Employment Concept* document. These three LOI were to examine the joint, interagency, multinational and public (JIMP) HQ design, a conceptual family of future combat vehicles, and the structure of an Army of Tomorrow optimized battle group (OBG). In this manner, the Land Futures Group would be able to inform complementary land staff projects and experiments scheduled to be undertaken in the near term. With respect to the OBG LOI, it is anticipated that its key findings will be used by Directorate of Land Force Development (DLFD) as the conceptual basis for future force structures commencing perhaps as early as the summer of 2007. In addition, the DLCD Designs Group is well positioned to leverage the findings of the LOI early in the capability gap analysis process that commenced in January 2007.

The OBG LOI was led by the Land Futures Shield function OPI throughout the conceptual phase. Specific input was sought from a number of key stakeholders (e.g., corps/branch

advisors, DLFD, force generating units, etc.) throughout the conceptualization of the experiment. This chapter will provide an overview of the project, examine its intended scope and context and outline methodology.

Affiliated Battle Groups

The OBG Experiment was selected as one of key research activities of DLCD in an effort to inform the CLS-directed transition to affiliated battle groups (ABGs).

For some time, consideration has been given to restructuring the land forces to resemble more closely the force employment models being presently used on operations. It is the intent of the CLS to progressively align land force force generation and force employment structures. The CLS stated that an ABG structure will allow unit commanding officers and their subordinate commanders the advantage of having most capabilities within the same unit for the purposes of cohesion, collective training and professional development. However, it is widely acknowledged that there will certainly be second- and third-order effects that will need to be fully investigated before permanent structural changes can be undertaken. It is envisioned that a significant proportion of this investigation will be undertaken under the auspices of the Optimized Battle Group Experiment.

It is further understood that the Army's structural evolution to an ABG model will be iterative and must be synchronized with a multitude of force development activities. In his planning directive, the CLS raised two fundamental questions. First, what is the optimal mix of capabilities to be grouped together in BGs to meet the challenges of the contemporary operating environment (COE) and future security environment (FSE)? And, second, what is the most effective force generation course of action for generating that optimal mix of capabilities?

The CLS envisions the structural evolution of the Army in two macro phases. Phase One is to focus on the "current build" of Army force structures. It is intended that this phase will leverage the experiences of Afghanistan and build upon formal affiliations which currently exist, while ensuring Army expansion targets the undermanned or new capabilities according to a yet-to-be-defined priority list. Additionally, this phase, i.e., the growth of capabilities in the current force, must meet the challenges identified in the *Land Operations 2021: The Force Employment Concept for the Army of Tomorrow*. Phase Two is highly dependent on the outcomes of DLCD's ongoing AoT capability development work. This phase is to include the AoT OBG Study. A subset of this study being a formed battle group experiment, centered on 2 Royal Canadian Regiment (RCR) at Canadian Forces Base (CFB) Gagetown, commencing in the fall of 2007.

The intent of the CLS planning guidance was to initiate a disciplined approach to leveraging the resident corporate knowledge and operational experiences within the ABG effort. The CLS charged COS Strategy with the lead for this analysis with the guidance that ABGs will be primarily a Regular Force structure focused on international missions with the Army reserve in support. A parallel Reserve Force structure, known as territorial defence battalion groups (TD Bn Gps), will focus on domestic operations with the Regular Force in support. The DLCD-led OBG Experiment is not meant to inform territorial defence battalion groups efforts.

Further to this general guidance, the CLS directed that particular attention be paid to several critical points. Overall, credibility, both internally and externally, remains the Army's centre of gravity. Combat effectiveness in an adaptive, dispersed environment remains vital, while the combined arms team remains essential to winning. The Army is to be composed of integrated and complimentary Reserve and Regular Force structures. A battle group must possess the full range of kinetic and non-kinetic capabilities. Afghanistan presents *a* good model, but does not necessarily represent *the* model, of the future security environment.

While the implementation of ABGs, and OBG experimentation, will by necessity focus at the battle group level, the CLS demands that related second- and third-order effects as they related to the Army's capacity to prosecute operations at the bde level be examined. The effects of moving toward an ABG model must be clearly defined and risk assessments completed. To that end, any ABG study and OBG experimentation must examine issues in terms of capacity, resource demands, pace of implementation, gross effect on rank, MOC and geographic locations. Further, broad impacts on the institutional Army are to be considered.

Optimized Battle Group Experiment

The optimization process will be guided and informed by the *Land Operations 2021: The Force Employment Concept* (FEC) and synchronized with other initiatives such as Army expansion, territorial defence battalion groups and Chief of Force Development's Force 2011 and Force 2021. In order to ensure that the optimum mix of capabilities and relationships are obtained, an AoT OBG Experiment will be conducted commencing in APS 07. The experiment scope will be broad, including examination of capabilities, structures, doctrine, procedures, equipment and force generation models.

In order to provide answers to a broad set of questions, the AoT OBG Experiment is envisioned to run indefinitely. As a minimum, it will run until 2011, when the Army expansion by 3060 PYs is forecast to be largely complete. Results from the experiment will be used to inform a series of decision points during Army expansion in order to ensure that the Army minimizes risk in its progress toward broad implementation of ABGs. While the land force, informed by a series of DLFD-led structures working groups, has already proposed Army expansion force structures, it is anticipated that lessons learned through OBG experimentation will allow for the adjustment of extant structures and the detailed design of follow-on structures.

Mission

The Army will conduct an AoT OBG Experiment with Second Battalion Royal Canadian Regiment (2 RCR) commencing in APS 07 in order to provide a professional, comprehensive and scientific approach to the development of the AoT OBG.

Execution

General Outline. The AoT OBG Experiment was initially conceived to be conducted in two phases, principally aligned with the DLFD–led Army Expansion Transitional Build 1 and Build 2 phases. While the DLFD Transitional Build Plan was reduced to one phase, it is anticipated that the two-phase approach to the OBG Experiment will remain valid. The image below provides a pictorial representation of the experiment and how it ties into other development

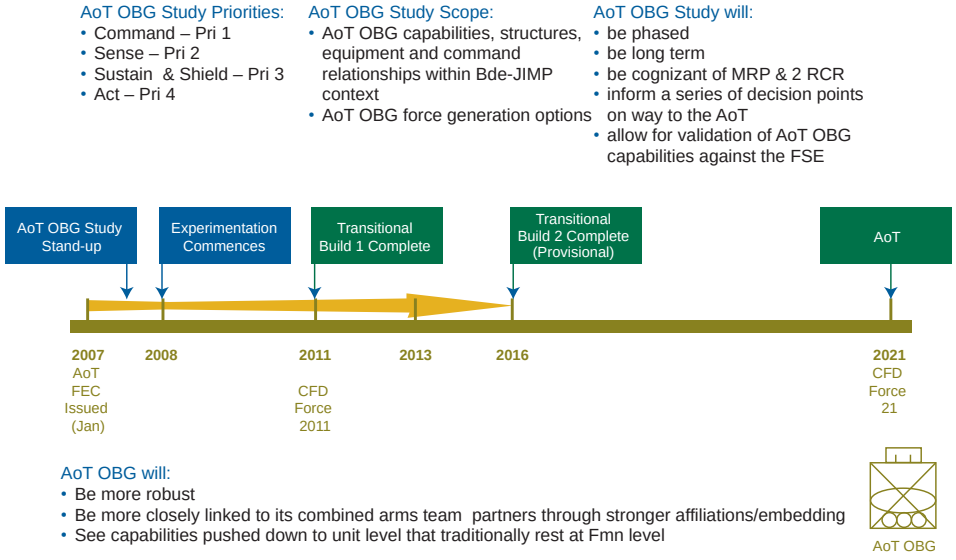
initiatives chronologically. The main focus of the DLCD conceive and design work will be APS 07. Direction for subsequent years will issued as the need dictates.

Figure 5-1: Progression Towards the Army of Tomorrow Optimized Battle Group (AoT OBG – 2 RCR)

Master Questions

1. *What is the optimal mix of capabilities to be grouped together in BGs to meet the challenges of the COE & FSE?*

2. *What is the most effective FG COA for generating that optimal mix of capabilities?*



CLS Intent. 2 RCR is designated the AoT OBG experimental unit. The experiment will have minimal impact on 2 RCR's availability within the Managed Readiness Plan (MRP). To the maximum extent possible, the experiment will make use of 2 RCR's extant training and operational activities to support experimentation work. Any additional task load will be captured in Canadian Forces Taskings, Plans and Operations (CFTPO) to ensure that 2 RCR / Land Force Area Atlantic (LFAA) are not unduly burdened by the experimental unit task. It is acknowledged that on its return from TF 1-07, 2 RCR will require time for reconstitution. Therefore, actual experimentation will commence with 2 RCR's regularly scheduled training, most likely in the January 2008 timeframe. An AoT OBG Experiment team, reporting to DLCD, will be co-located with 2 RCR to guide and oversee all aspects of the AoT OBG Experiment.

Endstate. The emphasis during the first year of study will be placed on command issues. To that end, by the end of APS 07, 2 RCR will have a baseline JIMP capability and embedded coordination centre enhancements. This will permit 2 RCR some time during the fall of 2007 to integrate the battle group HQ enablers prior to the commencement of formal experimentation activity. During this period, DLCD will take the lead in coordinating the development of a detailed experimentation plan. It is envisioned that by January 2008, the experiment team will be in place and ready to conduct and coordinate a broad range of experimentation activities in support of the AoT OBG Experiment. The additional enhancements for APS 08, such as the proposed mounted reconnaissance troop, have been identified and will have been briefed to the CLS for command direction by December 2007.

Tasks. The OBG Experiment requires the support of a wide variety of stakeholders. A number have been tasked to provide various aspects of support. Where currently anticipated, tasks have been defined in some detail. However, owing to the multi-year nature of this experiment, it is envisioned that many specific tasks will arise over time.

To date, the following stakeholders have been tasked:

- Land Force Doctrine and Training System (LFDTS). As the superior headquarters for Combat Training Centre (CTC) Gagetown, be prepared to provide experimentation support to the experiment team. It is envisioned that the CTC schools, as the centres of excellence for their respective combat arms, provide an excellent venue for some OBG capabilities geographically separated from their parent regiments (fire support, mounted reconnaissance) to maintain their core skills.

- Land Force Atlantic Area (LFAA). As the host land force area, LFAA is directed to provide experimental unit (2 RCR) and other elements, including the designation of an engineer squadron from 4 Engineer Support Regiment (ESR) as the affiliated squadron to 2 RCR. Furthermore, through 3 Area Support Group (ASG) / Gagetown, to provide vehicles and equipment to support trial. It is recognized that LFAA-based elements (2 RCR, 4 ESR, 3 ASG) will assume incremental costs associated with the experiment. It is intended that experimental-related costs will be ultimately paid out of the experimental budget.

- Land Force Central Area (LFCA). As a supporting land force area, LFCA is directed to provide a fire support coordination centre under operational control to 2 RCR. It is further intended that the sense sub-unit, minus, being stood up in Gagetown will be based on a Royal Canadian Dragoons (RCD) sub-unit. While Directorate Military Careers (D Mil C) staff will not likely draw solely from personnel currently serving in the RCD in Petawawa, it is likely that most of the armoured personnel being posted to Gagetown will come from this unit. As previously stated, CLS command direction on this issue will be required prior to any APS 08 establishment change activity.

- Directorate Land Strategic Planning (DLSP). DLSP is tasked to action the finalized APS 08 establishment changes once approved by CLS.

- Director Land Personnel Management (DLPM). DLPM is tasked to liaise between LS Comptroller, DLCD and D Mil C staff for costs moves in support of AoT OBG Experiment for APS 07. They are tasked to provide personnel input to AoT OBG enhancements for

APS 08 positions. Finally, they are to liaise with D Mil C staff for filling of positions/cost moves once CLS has approved AoT OBG enhancements for APS 08.

- Army G3 (Director Land Force Readiness [DLFR]). The Army G3 is tasked to provide managed readiness plan input for AoT OBG enhancements for APS 08.
- Director Land Force Development (DLFD). DLFD is tasked to provide resources to support AoT OBG enhancements for APS 08 (once approved by the CLS).
- Director Land Service Support (DLSS). DLSS is tasked to identify prospective candidate for officer commanding (OC) combat service support (CSS) company position. Further, they are to provide CSS input for the AoT OBG enhancements for APS 08.
- Land Force Provost Marshall (LF PM). The Army Provost Marshall is tasked to provide MP input for the AoT OBG enhancements for APS 08.
- Directorate of Land Command and Information (DLCI). As the organization responsible for communication infrastructure, DLCI is to provide Command Support and EW/SIGINT input for the AoT OBG enhancements for APS 08.
- Directorate of Land Concepts and Doctrine (DLCD). As the lead organization for the experiment, DLCD is to ensure the effective conduct of all aspects of the AoT OBG Experiment. As an interim step, a DLCD senior officer will fill the roles and responsibilities of AoT OBG Experiment team leader until such time as the on-site experiment officer is capable of commencing his duties. During the period September to December 2007, DLCD will take the lead in the development of the experimentation methodology and follow-on experimentation plan. Finally, DLCD will ensure that it provides DLFD with estimated costs for the experiment in FYs07/08 and 08/09.
- 1 Wing. As a short-term measure, COS 1 Wing has agreed to initiate the establishment of formal liaison between 403 Sqn and 2 RCR. In the long term, this formal liaison may continue or be substituted by a reserve position.

Experimentation Priorities

The experiment examines all operational functions in the following order of priority: (1) Command, (2) Sense—with examination of the concepts of an intelligence, surveillance, target acquisition and reconnaissance coordination centre (ISTARCC) at battle group HQ and the incorporation of a composite sense sub-unit in the battle group (based largely, though not exclusively, on the current recce squadron structure) inherent in the experiment—(3) Sustain and Shield and (4) Act.

APS 07 Priorities, Manning and Establishment Changes. As mentioned above, experimentation priority is initially to be placed upon the Command function. Efforts will focus on providing 2 RCR with a more JIMP-capable bn HQ and on embedding the coordination centres (CCs) and other planning functions in bn HQ. In essence, 2 RCR Bn HQ will be configured in peacetime much like that of a battle group HQ during operations. Thirty Reg F positions have been established/amended to support the experiment. The establishment change action on these positions has already been completed by DLSP and Director Force

Planning and Program Coordination (DFPPC) staff and is now with D Mil C staff for filling of the positions. Additionally, there is a requirement for ten class B reservists for civil-military cooperation (CIMIC), psychological operations (PYSOPS) and chemical, biological, radiological and nuclear (CBRN) capabilities.

APS 08 Priorities, Manning and Establishment Changes. While still subject to CLS command direction, in 2008 it is anticipated that priority will shift to the Sense function with the establishment of a composite RCD-based sense squadron (minus). Additionally, an MP section and a forward observation party are being considered. Staff checks will be conducted by DLCD staff to confirm the feasibility of including these additional elements in the AoT OBG Experiment in APS 08. These checks will consider second- and third-order effects arising from any such changes. Subject to CLS approval of proposed changes, the intent is to have the new positions sourced out of Army expansion credits. It is understood that establishment change action must be undertaken retroactively.

Other Agency Involvement. Given that the experiment mandate is broad, occasional involvement of other agencies is highly probable. Such involvement could include America, Britain, Canada and Australia (ABCA) / NATO partners, the Army Experimentation Centre (AEC), Director Land Requirements (DLR), the Land Force Trials and Evaluation Unit (LFTEU), Canadian Manoeuvre Training Centre (CMTC), the Army Lessons Learned Centre (ALLC), the various Army simulation centres and other CF organizations to name but a few. The experiment team will be responsible for identifying where other agency involvement would be appropriate and for conducting the requisite staff work to formalize that involvement.

Experimentation Timeline

Date	Event
Feb 08	Master implementation plan issued
May 07	Experimentation methodology coordination conference in Gagetown
Jun 07	Experimentation methodology issued
Aug 07	Stand up of OBG Experimentation Team; 2 RCR augmentee pers posted to Gagetown
Nov 07	AoT OBG Experimentation Team produces experimentation plan
Dec 07	CLS Command Direction on APS 08 activities
Jan 08	AoT OBG Experimentation activities commence

Service Support

It was conceived that all experimentation-related costs would be charged against dedicated project funds which have been allocated to DLCD. Funding is available for costs moves, reserve class B salaries, equipment movement, ASU Gagetown salary wage envelope (SWE) related directly to the AoT OBG Experiment, experiment team operations and maintenance (O&M) and experiment-related O&M costs to 2 RCR / 4 ESR.

Initial coordination determined that the extant 2 RCR infrastructure can accommodate the personnel and equipment arriving in APS 07. APS 08 infrastructure requirements will be considered as part of the staff checks in support of the APS 08 enhancements to 2 RCR.

Earlier staff checks with LFAA HQ staff indicated that there is sufficient quantity of vehicles in LFAA to support the experiment in APS 07. Initial coordination identified requirements of two M577 (fire support coordination centre [FSCC], ISTARCC) and four wheeled command vehicles (OC sense sqn, MP det comd, CIMIC det comd, CBRN det comd). And LFAA was tasked to notify DLCD of any costs associated with office/IS equipment for augmentee staffs in 2 RCR lines.

Command Issues

Sub-Unit Command. There have been two changes to traditional organizational models in the APS 07 timeframe. The OC administration company infantry major position in 2 RCR has been changed to OC CSS company' CSS major. This was done in recognition of the additional complexity and technical challenges of commanding of an OBG CSS sub-unit in the context of *The Force Employment Concept* (FEC) and adaptive dispersed operations (ADO). DLSS identified the prospective OC. Secondly, a sense sub-unit OC, who will be under full command of CO 2 RCR, was posted-in in APS 07. This OC will be responsible for leading the development of ISTARCC capability and concepts as well as for the composite sense squadron.

Methodology

The AoT OBG Experiment will make use of a broad range of methods to accomplish its work, including computer simulation/experimentation, operational research and analysis, research and development, human dimensions research and study, field trials and information exchange with other militaries and organizations.

DLCD subject matter experts (SMEs), along with the three-person on-site experiment team, will be responsible for identifying where other agency involvement is appropriate and for conducting the requisite staff work to formalize it. This may include, *inter alia*, ABCA/NATO partners, Directorate Land Synthetic Environments (DLSE), DLR, DLCI, LFTEU, ALLC, CMTC, Canadian Forces Experimentation Centre (CFEC), Land Personnel Concepts and Policy (LPCP), Chief Military Personnel (CMP) and non-military organizations.

General Questions

As previously noted, the experiment operational function priorities for the period July 2007 to July 2009 are, in order of priority, Command, Sense, Sustain-Shield and Act. As a starting point, a number of general questions are proposed for consideration in relation to each of these priorities. Development of a detailed experimentation plan will follow based upon the full range of potential questions for each operational function along with metrics appropriate for answering them. Given the challenges involved in attempting to measure the effectiveness of the OBG concept, it was proposed that Defence Research and Development Canada (DRDC) Centre for Operational Research and Analysis (CORA) establish an applied research project to supplement the experiment with robust OR resources.

The questions originally posed were as follows:

BG within a Bde Context. Which capabilities should normally be kept at bde or higher level, and which should be kept at battle group?

BG HQ Enhancements. The embedding of coordination centres and key planning elements in the battle group will be examined. Accordingly, and within the battle group HQ line of investigation, specific lines of inquiry are to examine whether the embedding of these elements permanently in the battle group HQ in peacetime enhances the overall effectiveness in the battle group's ability to plan and conduct operations and, if so, how and to what extent. The study will attempt to assess whether the embedding of these elements in the bn HQ has a detrimental effect on their core specific skills and knowledge, attributes and competencies and, if so, to what extent. It is of interest to determine whether the embedding of these elements impact on the core values or impact on Army ethos or professionalism. The study should also attempt to determine whether embedding these elements has an impact on unit morale and cohesion and on decision-making and trust.

JIMP-enabled HQ. In terms of the JIMP-enabled HQ, the embedding of CIMIC, PYSOPS and Pol/Dev Adv capabilities in the bn HQ will be examined. Specific lines of inquiry will determine whether the embedding of these elements permanently in the bn HQ in peacetime enhances the bn's ability to plan and conduct battle group operations. The study may propose other entities/specialists for embedding to further JIMP-enable the bn HQ. The competencies and attributes required for JIMP-enabled HQ staff and the effect of JIMP on the warrior ethic and Army values and professionalism will be identified. And "swift" trust issues surrounding JIMP-capable HQs will be examined in conjunction with ongoing work taking place through DRDC Toronto.

Command and Control Arrangements. A variety of command and control relationships have been established between the bn and its enablers. Accordingly, the experiment will attempt to identify and explain the optimum command and control arrangements between the bn and its enablers. Decision-making processes, trust, morale, cohesion, values, ethics, culture and communication will all be important considerations in such an evaluation.

Composite Sense Sub-unit Concept. Questions will involve the grouping of sense assets under OC recce sqn (supported by an ISTARCC embedded at bn HQ). The experiment must attempt to answer whether the grouping of sense assets in a single sub-unit enhances the overall effectiveness in the bn's ability to plan and conduct battle group operations. Furthermore, it must address how this proposed concept, for Army ABGs, might be refined to optimize the employment of sense assets within the OBG. The study will also examine whether there any new competencies or attributes are required as a result the bn HQ ISTAR concept.

Combat Service Support. In order to cope with the complexities of supporting ADO in the future security environment, the OBG proposes the evolution of the inf bn admin coy to a CSS coy. As such, the experiment must examine what impact, if any, amending the OC admin coy infantry major position to an OC CSS coy CSS major has. Also important is an examination of the changes required in the current admin coy to ensure that it is effective as

a CSS coy. The study must then examine how this evolution impacts on battle group culture, values, the operators-supporters relationship, competencies and attributes.

Working Relationships. Given that the experimentation team and 2 RCR (along with other effected units) are not in the same direct chain-of-command, attention must be paid to working relationships. Regular contact between the CO / Ops O 2 RCR and the experimentation team leader will help ensure that healthy and effective working relationships are established and maintained. Accordingly, 2 RCR (and other effected units) will keep the experimentation team apprised of unit training plans and operational activities. It will also assist the experiment team by accommodating experimentation activities within their normal training activities. And, the unit will ensure the experiment team has reasonable access to 2 RCR personnel, equipment and facilities when engaged in their work.

For its part, the experimentation team will make reasonable efforts to minimize any negative impact on 2 RCR and other affected units resulting from the conduct of the experiment. The Team will also advise 2 RCR (and other effected units) at the earliest possible opportunity of any experiment-related tasks or issues. Where tasks result in an additional burden to the unit, appropriate staff action will be taken to ensure that LFAA HQ is consulted and that the tasks are captured in CFTPO. It will ensure that any additional costs to 2 RCR (and other effected units) resulting from the experiment are funded through the experiment budget. During the conduct of the experiment, the team will ensure that it does not in any way interfere with the normal functioning of the chain-of-command within 2 RCR and any other units that are effected. And, in all experimentation reporting, conclusions or observations will be presented in a constructive, objective and professional manner.

Chapter 6

The Family of Future Combat Vehicles

By Lieutenant-Colonel Steve Fritz-Millet and Major Jim Terfry

As the 21st century unfolds, Canada continues to face an international arena marked by uncertainty, volatility and risk. While many threats have receded, others have grown in importance and still others have arisen in their place. The threats we now face are complex and often asymmetrical in nature. It is within this uncertain context that the land force must continue to operate to meet Canada's national security needs and expectations. This entails an inherent requirement to do so not only in the short term but also in the long term. As such, the Army must work towards a fuller understanding of the character of the future security environment and its implications for armed conflict. It must foster operational concepts and doctrine that are clear, relevant and forward-looking. Finally, it must seek capabilities, such as a family of future combat vehicles (FFCV), that ensure its effectiveness in the future battlespace at home and abroad.

To prepare the Army for the challenges it might face in the future, the Director General of Land Capability Development (DGLCD) was tasked to develop a force employment concept for the Army of Tomorrow. This document, formally endorsed by the CLS in February 2007, will act as the guide for land force development through to 2021. It is ambitious and forward thinking but at the same time well grounded in the lessons that we have captured from today's operations. In essence, it is a conceptual guide, from which force generation must evolve, acknowledging where we are, what we have achieved and what we must do to ensure continued success in the future.

In October 2006, the DGLCD directed that three single-issue lines of investigation (LOI) be undertaken in advance of the formal endorsement of the *Land Operations 2021: The Force Employment Concept* document. These three LOIs were to examine the joint interagency multinational public (JIMP) HQ design, the structure of an Army of Tomorrow battlegroup, and a conceptual family of future combat vehicles. In this manner, the Land Futures Group would be able to inform complementary land staff projects and experiments scheduled to be undertaken in the near term. With respect to the FFCV LOI, it is anticipated that its key findings and recommendations will be used by Director Land Requirements (DLR) as the conceptual basis for an FFCV acquisition project commencing perhaps as early as the summer of 2007. In addition, Land Futures is well positioned to leverage the findings of the LOIs early in the Capability Gap Analysis Process that commenced in January 2007.

The Family of Future Combat Vehicles LOI was led by the Land Futures section head (the Act function OPI). The project team consisted of the Land Futures Sense OPI, an operational researcher, and a representative from DLR.

Specific direction from DGLCD tasked Land Futures to investigate America, Britain, Canada and Australia (ABCA) concept development and experimentation (CD&E) activities (e.g., US Future Combat System [FCS], UK Future Rapid Effects System [FRES], Australian Land

400), the threats posed by the future security environment (FSE) and technology trends in order to determine what types of manned and unmanned vehicles should be included in the FFCV and what are the capability requirements of these vehicles. The Futures Group examined these issues in detail and also chose to consider several other factors such as the demands of the current operating environment, the expected end-of-service-life (EOSL) of our current fleet of vehicles and specific requirements of the Land Operations 2021 operating concept, adaptive dispersed operations (ADO). Taken together, these factors provide the basis for the LOI's recommendations with regard to the FFCV capability requirements and a proposed capability development framework.

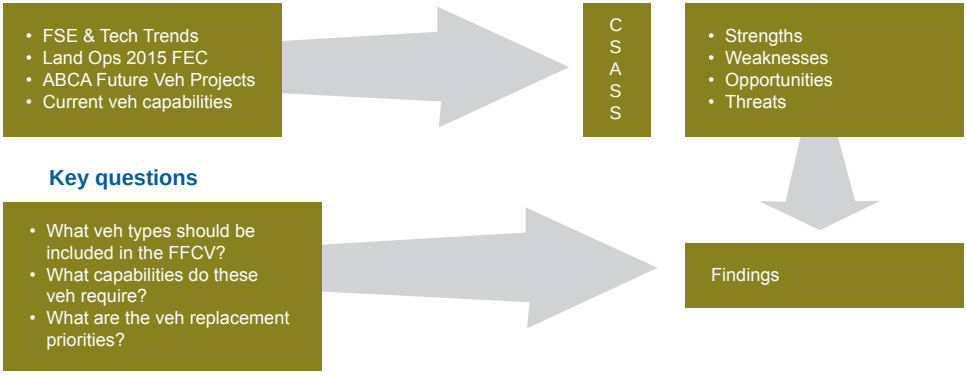
Purpose

This study proposes a capability-based framework which describes both broad capabilities and desired effect by platform variant for the FFCV.

Methodology

The analytical process undertaken by the study is graphically depicted in the following diagram and included the following steps:

Figure 6-1: The FFCV Study Process



The implications of the threats and challenges posed by the future security environment, the technological trends that may impact on future vehicle development, and the capability requirements of the *Land Operations 2021: The Force Employment Concept* were examined. A review of these three factors in relation to the operational functions (Command, Sense, Act Shield, and Sustain) led to the development of a number of implications for the FFCV.

The FFCV-related programs of the ABCA partners were assessed with a view to determining key deductions common to all or most, particularly with regard to broad system capability requirements.

The current Canadian Army fleet was examined in order to determine the end-of-service-life (EOSL) for each unique platform. Understanding of the EOSL of the current fleet provided

insights used to logically project the acquisition of FFCV platforms to meet projected vehicle capability deficiencies.

The findings of this analysis were then used to answer the key study questions related to FFCV vehicle types, capabilities and a supporting capability development framework.

Analysis

The Future Security Environment (FSE)

In general, the FSE will continue to exhibit high volatility and uncertainty. Already, ongoing trends (e.g., globalization, rapid scientific and technological innovation, demographic change, shifting regional power balances, the growing prominence of non-state actors) are leading to considerable change in the nature of conflict and its conduct. The result is that traditional threats and challenges are increasingly being eclipsed by newer dangers. While the prospect of inter-state war will not disappear, future challenges will be more diverse, with asymmetric attacks launched by transnational terror groups and the political instability, civil war and humanitarian crises characteristic of fragile countries making up the lion's share of turmoil in the early 21st century.

Increasingly, the likelihood of large force-on-force exchanges will be eclipsed by irregular warfare conducted by highly adaptive, technologically enabled adversaries, media-savy foes intent less on defeating armed forces than eroding an adversaries will to fight, rogue states bent on challenging the status quo, and trans-national criminal organizations ready, willing and able to buy, sell and trade everything from drugs to armaments for their own gain. Furthermore, turmoil will often occur in urban areas, with adversaries taking full advantage of the complex physical, moral and informational environments that large, densely populated cities provide.

To be sure, many of the broad contours of future conflict will resemble those present today. Yet a key difference will be that potential adversaries are likely to be even more adaptive and the threats they pose even more varied. Both globalization and exponential technological change will offer a wide array of actors the capacity to achieve a degree of influence and reach unlike anything seen in the past. This, combined with human ingenuity, will provide adversaries with an increased capacity to organize, network and mount significant challenges on a range of fronts—moral, political and military. With greater access to a range of "enablers"—including cell phones, the Internet and a wide array of weapons and weapon-related technologies—adversary mobility, reach and lethality will increase.

Implications of the FSE

The FSE will demand land forces capable of employing adaptive strategies and tactics that focus on the will and resolve of the adversary as well as on physical capabilities. It will also demand land forces ready and able to undertake offensive, defensive and stability type operations along a continuum from peace time military engagement to peace support to counter insurgency to major combat. These implications, in turn, necessitate a family of future vehicles capable of supporting full-spectrum engagement through integration and connectivity with the digital network, protection and lethality that can be easily adapted to changing operating environments, ensuring high on/off-road mobility, reduced deployability

and sustainability costs and ensuring a balance between affordability and state-of-the-art solutions.

Just as adversaries have adapted to western military superiority by seeking asymmetric advantage, the land force must continue to adjust to the realities of information age technological proliferation. The conceptual FFCV must be underpinned by technology and recognition of the intimate technological balance needed between firepower, mobility and protection, all of which are interdependent with a robust and adaptable network. Technology, therefore, will continue to be a fundamental enabler, allowing the soldier to be effective in the evolving security environment. Technology's impact, however, will depend on the manner in which it is used and by the quality and skills of the people leveraging it.

Technology Trends

While the continuing development and expansion of the Internet characterizes and defines the 21st century information age, from a military capability perspective, the basic tools of warfare (e.g., tanks, trucks, direct fire systems and missiles) remain remarkably similar to their industrial age predecessors. Though the integration of 21st century information technology into vehicle systems is notable, their basic physical performance characteristics are only marginally better than those of their Cold War predecessors. Propulsion systems and other mechanical components that define their physical performance characteristics are progressing at much slower rates than information technology or its uptake. Therefore, it will be primarily within the realm of information technology—with exponential improvements in rapid computation, simulation, situational awareness, targeting, surveillance, and precision—that the greatest increase in vehicle effectiveness will be witnessed.

Technology is currently being leveraged to gain the full strategic and tactical advantage of a mobile, agile and flexible force. This has led many armies to focus much of their development effort on fleets of lighter armoured vehicles that provide a credible and effective fighting force. While recent experience in the current operating environment has emphasized the shift to increased emphasis on protection with regard to the firepower- mobility-protection triangle and the need for heavy armour levels of protection in countering the IED threat, advances in materiel design and manufacture and information technology will be leveraged to enhance the protection of lighter weight forces. In this sense, survivability encompasses all successive layers of protection, from mobility and stealth to signature reduction and soft-kill defensive aids suites (DAS), to hard-kill DAS, to improved armour, to spall suppression systems.

While all passive armour will eventually be defeated, application of advanced engineering techniques is allowing for improved steel, aluminium and ceramic armour manufacture. Trends indicate that many more armour materials are becoming available, while advances in manufacturing technology continue to offer scope for improved armour performance. In particular, composite materials appear to offer the best mitigation of behind-armour effects.

Advances in vetronics are attempting to make vehicles usable with less training time. The vehicles, by necessity, will likely have to use commercial off-the-shelf (COTS) parts and software with an open architecture to permit a "fitted for but not with" capability. The rapid-deployment-with-limited-logistical-support ideology requires technology to provide fault reporting and built-in diagnostics to achieve quick and efficient repair, potentially reducing the

Implications of Technology Trends

In the future, leading edge technology will enable a medium-weight force to achieve the degree of lethality and protection formerly associated with a heavy force. The heavy lethality and protection capability requirements now provided by legacy heavy vehicles will, in time, be provided by advance technology, medium-weight systems with better capability in terms of mobility, modularity and upgrade potential. Until such time as industry produces medium-weight systems that provide current heavy lethality and protection capability, however, there will be a requirement for specific legacy heavy elements to reinforce medium and light forces to provide a higher degree of protection and lethality where required.

Other technology considerations for the FFCV that must be explored, include meeting the requirement for light-weight and maximum protection through an integrated approach to survivability that encompasses all of the successive layers of protection; leveraging non-ballistic protection, including stealth, deception and defensive aids where possible; exploring the promise of complex laminates, including ceramics, elastomers and explosives for offering good performance against a range of threats; exploring the possibilities for more fully embedding "future proofing" in system design by planning for future upgrades and weight increases due to bolt-on components; and, considering the merits of a mixture of lethal and non-lethal munitions for all weapon systems.

Land Operations 2021: The Force Employment Concept

The Land Ops 2021 operating concept, adaptive dispersed operations, seeks to create and sustain operational advantage over adept, adaptive adversaries through the employment of adaptive land forces alternatively dispersing and aggregating throughout the multi-dimensional battlespace. The complex, multi-dimensional and continually changing nature of the Land Ops 2021 operational framework requires land forces that are agile, capable of delivering both lethal and non-lethal effects, network-enabled, multipurpose and full-spectrum capable:

- **Agile** forces are capable of planning and conducting actions faster than the adversary can respond. Forces will also maintain the ability to respond to changes in the situation based on adversary actions faster than the adversary himself can exploit those changes.

- **Lethal and non-lethal** forces can engage the adversary with precision and non-precision lethal and non-lethal effects delivered by line-of-sight (LOS), non-line-of-sight (NLOS) and beyond-line-of-sight (BLOS) systems while manoeuvring to positions of advantage and conducting close engagement at the time and place of own choosing.

- **Network-enabled** forces operate within a network of land forces supported by joint sensor, fire support and C2 systems linked by voice and data to create a level of situational awareness, mobility and battlespace effects that combine to overwhelm the adversary's understanding of the battlespace and his ability to react.

- **Multi-purpose** forces provide full-spectrum capability derived from a combination of integral capability plus the full use of joint and coalition assets. Integral capability is founded, in turn, on a range of leading-edge technologies that provide enhanced

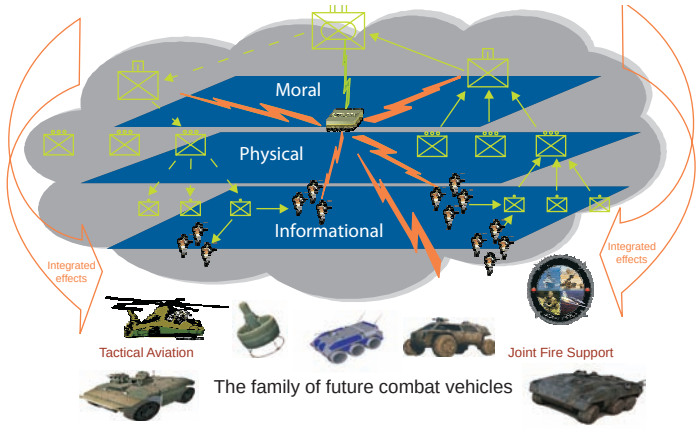
- **Multi-purpose** forces provide full-spectrum capability derived from a combination of integral capability plus the full use of joint and coalition assets. Integral capability is founded, in turn, on a range of leading-edge technologies that provide enhanced deployability, mobility, survivability, lethality and modularity. A multi-purpose force includes medium and light forces augmented as necessary by heavy elements. Medium forces exploit technology to achieve the level of lethality and survivability formerly provided by heavy forces, while light forces trade a measure of lethality and survivability for enhanced responsiveness, deployability and mobility. The high level of combat power inherent in medium forces is derived from both their integral capabilities and their ability to make full use of heavy elements and integrated effects. Light forces maximize flexibility and agility in order to compensate for reduced combat power and can be employed across the spectrum of conflict and continuum of operations in specific roles. Heavy elements reinforce medium and light elements to provide a higher degree of survivability and lethality where required by the force.

- **Full spectrum** forces are capable of participating in all aspects of a whole-of-government campaign plan across the entire spectrum of conflict.

Adaptive dispersed operations (ADO) envisage employing highly adaptive land forces dispersed—in terms of time, space and purpose—throughout the width and depth of the battlespace in order to create and exploit opportunities, control the tempo of operations and overwhelm the adversary's understanding of that battlespace. The essence of adaptive dispersed operations is the ability to conduct coordinated, interdependent, full-spectrum actions by widely dispersed teams across the moral, physical and informational planes of the battlespace ordered and connected within an operational design created to achieve a desired end state. The fundamentals of dispersed operations, developed from the manoeuvre principles of find, fix and strike, include: developing situations prior to contact; manoeuvring to positions of advantage; influencing the adversary beyond the range of his weapons with lethal and non-lethal capabilities; destroying the enemy, when necessary, with precision and area effects; conducting both lethal and non-lethal close engagement at the time and place of own choosing; and, transitioning between operations without loss of focus or momentum.

These fundamentals are applied across the moral, physical and informational planes of the battlespace. In short, adaptive dispersed operations call for networked and integrated land manoeuvre forces supporting and supported by JIMP-integrated effects alternatively dispersing and aggregating over extended distances to identify, influence and defeat full-spectrum threats throughout the multidimensional battlespace.

Figure 6-2: Adaptive Dispersed Operations



Implications of the Land Ops 2021 Force Employment Concept

The underlying implication of the *Force Employment Concept* is the need for an integrated family of vehicles that enable participation in all aspects of a whole-of-government campaign plan across the entire spectrum of conflict by an adaptive, dispersed land force. The synergestic integration of the vehicle family with other CF integrated effects such as joint fire support (JFS) and tactical aviation is crucial to the FFCV capability.

Summary

In sum, the characteristics of the FSE, technology trends and the *Force Employment Concept* call for an FFCV fleet that, on whole, is balanced, agile, and possesses a full spectrum capability. This implies the family possesses a mix of both medium- and light-weight force capabilities. Medium-weight forces will leverage technology to deliver high levels of lethality and protection, while light forces will trade some lethality and protection for better levels of mobility, agility and flexibility. Until such time as advanced technology is able to deliver heavy levels of protection and lethality at medium weight, a heavy element will be required to augment medium and light forces in specific situations. The family must be agile, both strategically and operationally, in terms of force projection and sustainment as well as possessing effective mobility throughout the tactical battlespace. The family must also be JIMP / integrated effects capable, possess full-spectrum protection against a wide range of threats (kinetic energy, chemical energy, non-lethal, etc.) and offer a full-spectrum weapons capability. In order to profit from the predicted advances in technology, the FFCV must also be network enabled, permit the employment of modular protection, offer enhanced mobility, possess improved threat detection capabilities, permit the adoption of smaller crew sizes and common functions, and incorporate robotics and autonomous systems.

Parallel Efforts: Ongoing ABCA Future Combat Vehicle Projects

As part of their force development activities, the United States, United Kingdom and Australia are all engaged in the development of what is essentially national families of future combat vehicles. The three programs will be briefly reviewed with a view to divining the key deductions

common to all or most. While the development of the FFCV will be based on the forecast capability requirements of the Canadian Army conducting land operations in the FSE of 2021, the review of partner programs serves as a useful comparison, particularly in light of the assessed importance of coalition operations in future.

US Army Future Combat System

The US Army's Future Combat System (FCS) is the Army's modernization program consisting of a family of manned and unmanned systems connected by a common network. FCS has 18 broad system categories, with many variants within each category. It consists of unattended ground sensors (UGSs); two unattended munitions (the Non-Line-of-Sight—Launch System [NLOS-LS] and Intelligent Munitions System [IMS]); four classes of unmanned aerial vehicles (UAVs) organic to platoon, company, battalion and brigade combat team (BCT) echelons; three classes of unmanned ground vehicles (the Armed Robotic Vehicle [ARV], Small Unmanned Ground Vehicle [SUGV], and Multifunctional Utility/Logistics and Equipment Vehicle [MULE]); and, the eight manned ground vehicles (18 individual systems) plus the Network (18+1) plus the Soldier (18+1+1).

UK Future Rapid Effect System

The United Kingdom's Future Rapid Effect System (FRES) programme will provide the British Army with a family of medium-weight, network-enabled, air-deployable armoured vehicles to meet up to 16 battlespace roles. While the Army will retain its existing heavy and light fleets, FRES will be the central pillar of a highly deployable medium force, which will be able to project power rapidly world-wide, complementing existing heavy and light forces. The interim operating capability platforms will be utility vehicles performing protected mobility, medical and command and control roles. Later specialist variants that will make up the full operating capability are likely to comprise variants including communications, reconnaissance, direct fire, indirect fire and guided weapons platforms and mobility and counter mobility roles.

Australia Land 400

Building upon the current Australian Army restructuring project (the Hardened Networked Army [HNA]), the Australian Land 400 program is designed to enhance the survivability and combat effectiveness of ground forces in close combat through the provision of a cost effective, integrated future combat vehicle system (FCVS). The overall capability is expected to deliver an FCVS which incorporates platforms capable of being employed across a wide range of variants: IFV, APC (infantry mobility, mobility enhancement and counter-mobility), a C2 variant (including a network support role), reconnaissance and surveillance, observation post vehicle (fire coordination and direction), medical evacuation, maintenance and recovery (may be separate platforms), logistic support (combat supplies), air and missile defence and mortar carrier. While not as broad as FCS, Land 400 is complimented by other recent programs such as Land 17 (self-propelled/towed 155 mm acquisition) and Land 907 (mounted combat system [M1A1] acquisition), which, when viewed as a whole, represent a full spectrum of capabilities.

Implications of Allied Future Combat Vehicle Projects

While each program serves to fulfill unique national military requirements, comparison of proposed vehicle types and capabilities reveals a number of commonalities. The following

table outlines a basic comparison of these future combat vehicle types by operational function:

Vehicle Capability	FCS (US)	FRES (UK)	Land 400 (AUS)
Command	♦	♦	♦
Comd Sp—Comd/Ln	X	X	X
Comd Sp—C3	♦	♦	♦
Comd Sp—EW	♦	♦	♦
Recce—Lt	X	♦	X
Recce—Med	♦	♦	X
Recce—CBRN	♦	♦	X
Surveillance	♦	♦	♦
UGV—Surveillance	♦	X	X
UAV—BG+/Coy/Pl	♦ ♦ ♦	XXX	♦XX
Armd Security Veh	X	X	X
Manoeuvre—Lt	X*	♦	♦
Manoeuvre—Med	♦	♦	♦
Mounted Combat System	♦	X	♦
DFS—Gun	♦	♦	X
DFS—Missile	X	♦	X
Indirect Fire—Gun/Mortar	♦	♦	♦
Indirect Fire—Missile/Rocket	♦	♦	X
UGV—Assault	♦	X	X
GBAD—C-RAM**	X	♦	X
Manoeuvre Support—Engineer Gap	X	X	X
Manoeuvre Support—Engineer Breech	X	♦	X
Manoeuvre Support—Engineer Dozer	X	♦	♦
UGV—Counter Mine	♦	X	X
Protected Cargo Mine	X	♦	♦
Sustain—Med—CASEVAC	♦	♦	♦
Sustain—Med—Trauma	♦	X	X
Sustain—Recovery	♦	♦	♦
Sustain—Repair	♦	♦	♦
UGV—CSS	♦	X	X

*[285]

**[286]

285 While not a formal component of the FCS, the US Army and USMC are acquiring the Joint Light Tactical Vehicle (JLTV) as a High Mobility Multipurpose Vehicle Wheeled (HMMVW) replacement. See http://contracting.tacom.army.mil/ssn/jltv.htm.

286 Counter rocket, artillery and mortar.

Beyond simple platform similarities, however, the projects had numerous system attributes in common. These, similarities were apparent in a number of categories, including:

- **Balance**. Fleets either include a range of medium and light vehicles to represent a balanced force (FCS) or draw linkages to existing heavy and light capabilities (FRES and Land 400).

- **Mobility**. Fleet capability requirements address both battlefield operational and tactical mobility, such as independent, self-protected transit, as well as strategic and administrative transportability requirements.

- **Scalable Protection**. Fleets possess scalable protection that must incorporate the entire continuum of survivability (signature, active protection, passive protection, mitigation of behind armour effects, repair) that can be optimized for a range of conditions.

- **Scalable Lethality**. Fleets possess scalable lethality. Effects are expected to be integrated into the joint fire support capabilities. Individual system platforms are not expected to provide the whole range of lethality effects required by the capability. The system lethality capability should demonstrate a level of scalability in order to tailor lethality systems to the threat level.

Additionally, the vehicle is viewed as a network node for the dispersed soldier. To ensure that data gets to the right place, the network is built as a distributed web with every vehicle and every soldier acting as a node, so if any node fails, the data will flow around it. Sustainment for future fleets is focused on increasing operational availability and reducing the logistics footprint. The aim is to lower the total sustainment burden in order to maximize combat capability. The support systems are optimized to envision vehicles that have an embedded training capability, commonality within respective fleets, utilize standard training platforms and, where possible/practical, are interoperable with allied/coalition fleets.

Finally, and while not included in the FCS or FRES programs, it should be noted that, both the US and UK armies plan to maintain their main battle tank (MBT) capabilities (M1 Abrams and Challenger) until out to 2050 and 2035 respectively. It is envisioned that these platforms, along with Bradley and Warrior infantry combat vehicles, will provide a legacy heavy force in addition to the FCS and FRES medium-weight future capability. The Australian Army has not formally indicated how long it expects their fleet of 59 recently acquired M1A1 Abrams Integrated Management (AIM) systems to remain in service.

The Current Canadian Vehicle Fleet

The Canadian Army's current fleet of combat vehicles range in age from over 30 years (Leopard and M113, albeit with significant upgrades), to relatively new systems acquired in the 1990s (e.g., Light Armoured Vehicle [LAV] III). While it would seem intuitive that older platforms would reach their end-of-service-life sooner, the attrition of some newer platforms (LAV III) in current deployed operations has potentially brought the requirement for a replacement forward. The following table represents the current Canadian vehicle fleet, by broad capability and expected end-of-service-life (EOSL) date:

Capability	Platform	Expected EOSL Date	Remarks
Comd Sp—Comd	LAV III CP	2030	Replacement currently unknown.
Comd Sp—C3	Bison C3I	2025	Supportable to 2025. Current overweight conditions, which may degrade mobility to unacceptable levels, may drive earlier replacement or significant upgrade to driveline.
Lt Recce	LUVW Recce	2025	
Medium Surveillance	Coyote	2011	LE reqr 2010-2016 due to obsolescence of surveillance suite. Current overweight conditions, which may degrade mobility to unacceptable levels, may drive earlier replacement or significant upgrade to driveline.
UAV—Bn	Sperwer		
UAV—Coy	Skylark		
Medium Manoeuvre	LAV III	2030	Unknown replacement.
Medium Manoeuvre	TLAV FOV (M113A3)	2028	
Light Manoeuvre	LUVW	2025	
Light Manoeuvre	RG-31 Nyala	2021	
Direct Fire—Missile	LAV TUA	2030	
Protected DF—Gun	Leopard C2	2015	Turrets not supportable past 2015. Potential Battle Tank replacement project 2008-2015.
Indirect Fire—Gun	M777	2030	
Manœuvre Sp—Gap	Leopard AVLB (Beaver)	2020	Leo variants could be kept in service slightly longer than tank variants.
Manœuvre Sp—Breech	Leopard (Badger)	2020	
Hvy Sp Veh—Cargo	HLVW	2023	
Mobile Repair	HLVW MRT	2023	
Heavy Recovery	Leopard ARV	2020	
Medium Recovery	HLVW Recovery	2023	
CASEVAC	Bison Amb	2025	Current overweight conditions, which may degrade mobility to unacceptable levels, may drive earlier replacement or significant upgrade to driveline.

Source: DLR EOSL Brainstorming Session, 22 February 2007.

Implications of the Current Canadian Fleet End of Service Life

The FFCV capability development prioritization must inform any proposed current fleet replacement priorities. While the EOSL of the current fleet helps to identify future capability gaps, any FFCV acquisition program must be designed to address a broad range of issues. To that end, any proposed capability development priority shall consider the demands of adaptive dispersed operations, the overall benefit of investment (strategic adaptability) in any particular capability/platform and the requirements of the current operating environment. It shall also be mindful of the force projection capability delivered by each platform. In terms of risks, any prioritization will consider the operational risk posed by the absence of a specific platform, particularly in relation to the EOSL of current platforms and the capabilities they represent. Finally, any prioritization will consider the current state of technology with a view to identifying those capabilities which may be delivered sooner and those which require additional R&D effort. In order to generate a capability development priority list with all these factors in mind, a Fundamental Investigation of Defence Objective (FIDO) scoring approach will be employed.

Findings

The Conceptual Family of Future Combat Vehicles

A family-of-vehicles approach was adopted as a means of meeting the FFCV requirement for an integrated, modular family of advanced-technology medium and light vehicles, including unmanned ground and air vehicles, that enable full-spectrum engagement across the five operational functions in support of adaptive dispersed operations. Such an approach to capability development provides a number of advantages in terms of standardization and interchangeably, economies of scale and in helping to ensure reduced training, maintenance and support costs.

The FFCV concept is founded on the synergistic integration of the soldier, the manned vehicle and the unmanned system. Consequently, although not a part of the FFCV, the soldier capability as envisioned by the Integrated Soldier System Program (ISSP) is an integral part of the FFCV system of systems. Canadian Forces delivered integrated effects such as joint fire support and aviation support should also be considered integral to the FFCV concept.

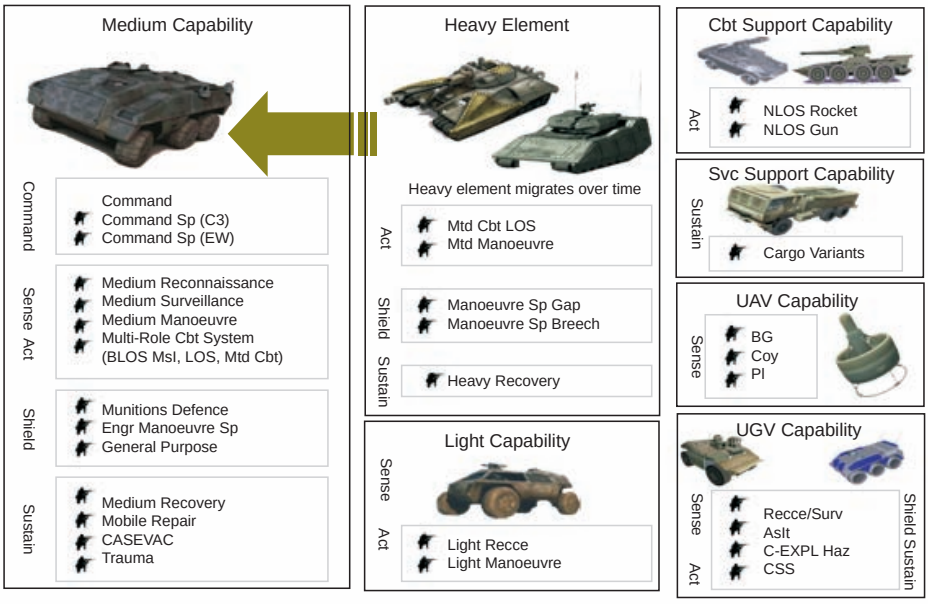
Network-enabled operations, as envisioned by adaptive dispersed operations, require a network of troops and supporting elements on the ground, supported by joint sensor, fire support and command and control systems linked by voice and data to create a level of situational awareness, battlefield mobility and ground effects that combine to overwhelm the adversary's understanding of the battlespace and his ability to conduct operations. Also fundamental to the FFCV concept is the networking of the FFCV to the remainder of the operating systems, be they manned or unmanned.

An operationally effective FFCV should include the following combat vehicle capabilities:

- Medium Capability
- Light Capability
- Interim Heavy Element

- Combat Support Capability
- Combat Service Support Capability
- Unmanned Air Vehicle Capability
- Unmanned Ground Vehicle Capability

Figure 6-3: The Family of Future Combat Vehicles



The table at Annex A describes the general purpose of each vehicle, the common capabilities inherent in each as well as the envisioned capabilities of each variant of the vehicle. For the purpose of this FFCV description, the following definitions have been used:

- **Destruction**. The destruction of a target means that it can no longer be used for its intended purpose without major repair, reconstruction of replacement.
- **Neutralization**. The neutralization of a target means that it cannot conduct its intended role for the period chosen by own forces. Neutralization includes preventing threat force manoeuvre and therefore requires application or threat of physical damage to the target to prevent movement. Screening or spoofing can also achieve neutralization.
- **Vehicle weights**. Light Vehicles are considered less than 20 tonnes in combat weight. Medium armoured vehicles are considered those over 20 tonnes and under 40 tonnes in combat weight. Heavy Armoured vehicles are over 40 tonnes in combat weight.

- **Static Targets**. Unimproved static targets are considered to be natural features such as trees, lying deadfall and scattered rocks. Unimproved static targets may also be considered to be unmodified urban elements, such as accommodation, office blocks or light bridging structures. Lightly protected static targets include reinforced domestic, industrial and commercial structures. Heavily protected static targets include reinforced concrete domestic, industrial and commercial structures as well specially constructed above-ground military structures.

Capability Development Themes

Based on the findings of this study, any FFCV acquisition project should be implemented in accordance with the following four premises:

- The FFCV capabilities are developed and acquired as part of an integrated system of systems in synchronization with ISSP and development of the network.
- Where possible, spiral development is undertaken to complement existing vehicle capabilities.
- Where possible and practical, modularity should be incorporated within platforms and throughout the system as a whole.
- The acquisition of specific combat vehicle capabilities should be phased in order to minimize capability gaps given the expected EOSL of the existing combat vehicle fleet.

Capability Development Priorities

Based on the above capability development themes, additional rigorous examination of all proposed vehicle capabilities was undertaken against an established set of benefit criteria. Given the multi-dimensional nature of the problem, and in order to ensure broad-based input to the development of acquisition priorities, this examination was done through a Fundamental Investigation of Defence Objectives (FIDO) ranking exercise, which captured the input of a wide range of Army (Directorate of Land Concepts and Doctrine [DLCD], Director Land Requirements [DLR], Directorate of Army Training [DAT], Director Land Force Development [DLFD]) and scientific community (Defence Research and Development Canada [DRDC], Assistant Deputy Minister Material [ADM(MAT)], Op Research) stakeholders. This FIDO examination used the following benefit and weighting criteria:

Benefit Criteria

- **Demanded by the Adaptive Dispersed Operating (ADO) Concept**. Platform that provides the best combination of attributes/capabilities that will facilitate the implementation of ADO (i.e., leading edge capabilities that provide enhanced mobility, survivability, interoperability, modularity and component commonality).
- **Strategic Future Adaptability**. Platform that provides the most significant leap in force innovation and offers the greatest evolutionary modernization potential.
- **Demanded by Contemporary Operating Environment (COE)**. Platform that provides the best combination of attributes/capabilities that address the current challenges

(mobility, firepower, protection, sustainability, system-level integration, networking) of the COE.

- **Force Projection**. Platform that provides the best combination of attributes/capabilities that will facilitate deployability (i.e., designed for rapid air transport) and can be employed in most potential theatres, with the smallest logistic footprint.

Weighting

The benefit criteria were weighted to place emphasis on the demands of ADO (40%) and strategic future adaptability (30%). Demands of the contemporary operating environment (20%) and force projection (10%) were given comparatively less weight. These weights were assigned to ensure that any resulting capability priorities for the FFCV were future-focused. Notably, the conduct of several rankings indicated that regardless of what weighting was applied, the relative rank order of the platforms remained largely consistent. For example, medium platforms typically scored higher, while heavy platforms scored lower.

Based on the relative advantages and disadvantages of each platform against the four weighted benefit criteria, the FIDO examination produced the following recommended aggregate ranking of capability priorities. A more detailed picture of the FIDO scoring results is offered in Annex B.

Table 6-3: Capability Development Priorities

Rk	Platform	Rk	Platform	Rk	Platform
1	MedVeh—Manoeuvre	12	UAV—Level 1 (BG)	23	Med Veh—Recovery
2	LightVeh—Reconnais-sance	13	UAV—Level 2 (Coy)	24	Med Veh—Mobile Repair
3	Med Veh—Multi-Role Cbt Sys	14	Med Veh—Engr Man Sp	25	Hvy Veh—Mtd Cbt LOS Fire Sp
4	Med Veh—Command	15	Med Veh—General Purpose	26	Hvy Veh—Manoeuvre
5	Med Veh—Reconnais-sance	16	Med Veh—Trauma	27	UGV—Assault
6	Med Veh—Surveillance	17	UAV—Level 3 (PI)	28	UGV—CSS
7	Med Veh—Comd Sp (C3)	18	NLOS Fire Sp—Rocket	29	Hvy Veh—Engr Gap Sp
8	Light Veh—Manoeuvre	19	UGV—Recce/ Surveillance	30	Hvy Veh—Engr Breach Sp
9	Med Veh—Comd Sp (EW)	20	UGV—Counter Explosive Hazard	31	Sp Veh/Cargo—Hvy Sp Veh
10	Med Veh—CASEVAC	21	Med Veh—Munitions Defence	32	Hvy Veh—Hvy Recovery
11	NLOS Fire Sp—Gun	22	Sp Veh Cargo—Med Sp Veh		

In short, the FIDO recommendations can be summarized to conclude that medium and light FFCV capabilities be developed as the highest priority, followed by an NLOS capability, UAV and select UGV capabilities respectively. The broad conclusion of the FIDO exercise suggests that heavy capabilities represent the lowest priority for capability development within the FFCV. Furthermore, it should be noted that a subsequent "schools of thought" analysis of the FIDO scoring process revealed no significant divergence of opinion between the varied stakeholder groups.

Note on Acquisition

It is important to make a distinction between this study's stated capability development priorities and any subsequent acquisition priorities. In keeping with the conceptual nature of this document, the FIDO ranking exercise has allowed us to determine which platforms offer the most relative benefit to the FFCV and ADO in general. That said, the highest rated platforms, e.g., the multi-role combat system, may not necessarily be ideally suited for immediate acquisition owing to the current state of vehicle technology or other factors. These priorities should be viewed as the *start point* for any future acquisition decision-making. Any platform acquisition prioritization must be considered against a wide range of other requirements such as current operational requirements, clearly identified capability gaps in the current fleet and available technologies.

Benefit-Risk Analysis

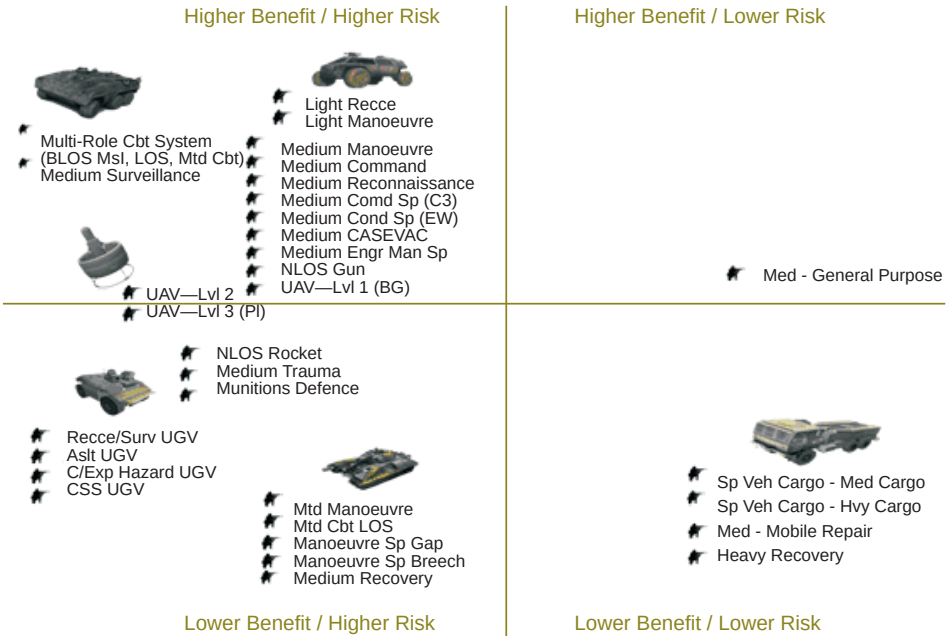
The FIDO scoring participants also ranked each platform against the four previously identified benefit criteria and two risk criteria. The risk criteria were as follows:

- **Operational Risk**. The potential risk that the Army will not be able to complete its assigned tasks or missions if it is unable or unwilling to implement a particular vehicle project. To emphasize the relative importance of this factor, a weighting of 60% was assigned.

- **Technical Feasibility.** The risk that the enabling technologies would not be sufficiently mature to fully implement a given vehicle system (i.e., this risk criterion measures technical or project feasibility or likelihood for success). This factor was assigned a weighting of 40%.

The aggregate benefit rankings were subsequently compared with the aggregated risk rankings. This allowed identification of those platforms that offer the greatest benefits to the FFCV and pose the greatest risk of system failure if they are unavailable. This comparison identified the multi-role combat system and the medium surveillance system as the two platforms providing the greatest benefit and posing the greatest risk to operations if they were absent from the family. The light platforms and the majority of medium platforms were also seen as offering a higher benefit and posing a higher risk of mission failure if they were absent. The UGV family was shown to offer comparatively less benefit to the FFCV, while it also posed a high risk of implementation (arguably due to the current state of UGV technology). The support vehicles—cargo, heavy recovery and medium repair platforms—were found to offer a lower benefit to the system; however, owing to the availability of technology, it was felt that these systems could be developed and acquired with lower risk.

Figure 6-4: Aggregate Benefits vs. Risk (Operational and Technical)



Initial Investment Opportunities

A comparison of the benefit-risk and related cost-value assessments highlighted a few platforms which the FIDO ranking determined as offering the greatest potential value and benefit, at the lowest unit cost, while posing the greatest risk to mission success if they are absent from operations (See Annex B). It is recommended that the following platforms be pursued as initial investment opportunities through either R&D/experimentation or through acquisition:

- Light Manoeuvre
- Light Reconnaissance
- Medium Manoeuvre
- Medium Command
- Medium CASEVAC
- UAV—Class 1 (BG level)
- UAV—Class 2 (Coy level)

Recommended Future Research and Experimentation

It is recommended that initial research and experimentation focus on those FFCV platforms which have been identified as having a higher benefit value and those which have been identified as having a high value relative to the operational risk posed by their absence. FFCV-related R&D undertaken by DRDC shall be incorporated into our growing body of knowledge. DLCD will remain engaged in the R&D effort through the Thrust Advisory Group process, while Army Experiments 9B, 9C and the 10 series offer further opportunities for operational research and concept and design refinement. Recommendations are as follows:

- As the top priority, research into a medium vehicle platform which meets the FFCV stated capability requirements as the replacement for the LAV III platform.

- Research into a light vehicle platform which meets the FFCV stated capability requirements in terms of to improved survivability, sustainability, growth potential, mobility and automotive safety balanced with the total cost of ownership. Vehicles also must meet current weight and dimension requirements for transportability by aircraft and helicopter. The Joint Light Tactical Vehicle (JLTV) program may offer some leverage opportunities.

- Research into light and medium reconnaissance capabilities. Research into on-board data/information fusion capabilities for deployed and networked sensors. Definition of on-board sensor requirements (EO/IR), and capacity for UAV and UGV integration. Examination of optimal operating concept and force structures.

- Research into medium surveillance systems. In particular, the capacity for modular surveillance/sensor systems.

- Research into NLOS rocket and gun systems. Further research is required to determine capability requirements to support ADO. Experimentation into how these systems may integrate into both the FFCV system of systems and joint fires. And determination of what mix of gun and rocket capabilities are required to conduct ADO.

- Research into multi-role combat systems. Continued research into the feasibility of, and technologies required for, integrating BLOS missile, LOS gun, and mounted combat capabilities on single platform. Effort should be directed toward modular systems.

Conclusion

The results of the FFCV study, and the FIDO analysis in particular, reveal that the move toward a technology-based, medium-weight, balanced force is best suited to meet the challenges of conducting ADO in the FSE. While the FFCV will be predominantly medium weight, there will be a requirement for some light platforms offering improved operational and tactical mobility, particularly as technology improves these platforms' survivability. Conversely, the benefits of heavy elements will be short-lived, as technology delivers improved survivability and lethality to medium platforms. The analysis supports the conclusion that, as a priority, short-term R&D should be directed toward LAV III fleet replacement by another, technologically advanced, medium-weight platform.

Annex A to Chapter 6
The Family of Future Combat Vehicle Capabilities

Light Capability				
Serial	Vehicle	Description	Capability	Capability Description
1	Light Vehicle	This vehicle provides mobility and limited protection against direct, indirect and IED attack. The light vehicle trades a measure of protection and lethality for enhanced agility, mobility, and deployability.	Mobility	Strategic—C17, ship transportable. Operational—Road, rail, heavy helo, STOL, slung by heavy lift helicopter. Tactical—Enhance on/off road.
			Knowledge	C3—Networked C2 and situational awareness. Sensors—Day and night weapons sight, basic level of CBRN detection.
			Survivability	Signature—Lower signature levels across all spectrums when compared with legacy systems. Provide best available protection given other constraints against kinetic, chemical, blast and fragments to protect crew, passengers and vehicle. CSS behind armour effects—Multiple redundant mitigation measures for the protection of crewmembers. Repair—Forward, rapid repair of attack damage and isolation of other systems from secondary damage.

Light Capability				
Serial	Vehicle	Description	Capability	Capability Description
			Lethality	To an effective range of 1200 m, during day and night and while static and moving, the weapons systems on the vehicle should provide: • Neutralization and destruction of dismounted troops, unprotected transport vehicles, light vehicles and unimproved static targets. • Neutralization of light armoured vehicles and lightly protected static targets. • Coordination and direction of FFCV integral firepower • Coordination and direction of joint/ coalition firepower.
			Sustainability	Optimize the level of component commonality within class. Use of novel technologies to reduce fuel consumption.
			Growth Potential	The largest and heaviest variant of this class must be considered as its base vehicle, and then growth potential added to it to enable the addition of weight of add-ons for future modifications and load carrying.
1a	Manoeuvre	Provides transportation for a section.	Mobility	Same as serial 1.
			Knowledge	
			Survivability	
			Lethality	
			Sustainability	
1b Sensors—enhanced CBRN sensors, deployable unmanned ground sensors, platoon-level UAV	Reconnaissance	Provides transportation for a reconnaissance detachment.	Mobility	Same as serial 1.
			Knowledge	C3 ability to fuse data from integral sensors (on the vehicle and dismountable from the vehicle) with those available throughout the FFCV.
			Survivability	Same as serial 1.
			Lethality	
			Sustainability	

Light Capability				
Serial	Vehicle	Description	Capability	Capability Description
2	Medium Vehicle	This vehicle provides mobility and protection against direct, indirect and IED attack.	Mobility	Strategic—C17, ship transportable. Operational—Road, rail, C130. Tactical—Enhance on/off road.
			Knowledge	C3—networked C2 and situational awareness. Sensors—EO and IR weapons sight, basic level of CBRN detection.
			Survivability	Signature—Lower signature levels across all spectrums when compared with legacy systems. Provide best available protection, given other constraints against, kinetic, chemical, blast and fragments to protect crew, passengers and vehicle. Behind armour effects—Multiple, redundant mitigation measures for the protection of crewmembers. Repair—Forward, rapid repair of attack damage and isolation of other systems from secondary damage.
			Lethality	To an effective range of 1200 m, during day and night and while static and moving, the weapons systems on the vehicle should provide: • Neutralization and destruction of dismounted troops, unprotected transport vehicles, light vehicles and unimproved static targets. • Neutralization of light armoured vehicles and lightly protected static targets. • Coordination and direction of FFCV integral firepower • Coordination and direction of joint/ coalition firepower.

Light Capability				
Serial	Vehicle	Description	Capability	Capability Description
			Sustainability	Optimize the level of component commonality. Use of novel technologies to reduce fuel consumption.
			Growth Potential	The largest and heaviest variant of this class must be considered as its base vehicle and then growth potential added to it to enable the addition of weight of add-ons for future modifications and load carrying.
2a Neutralization and destruction of light armoured vehicles and lightly improved static targets Neutralization of heavy armoured vehicles and heavily protected static targets	Manoeuvre	Provides a manoeuvre capability for an infantry section.	Mobility	Same as serial 2.
			Knowledge	
			Survivability	
			Lethality	To an effective range of 2500 m, during day and night and while static and moving, the weapons systems on the vehicle should provide: • Neutralization and destruction of light armoured vehicles and lightly improved static targets. • Neutralization of heavy armoured vehicles and heavily protected static targets.
			Sustainability	Same as serial 2.
2b Neutralization and destruction of light armoured vehicles and lightly improved static targets Neutralization of heavy armoured vehicles and heavily protected static targets	Command	Provides a manoeuvre capability for unit, sub-unit and sub-sub-unit commanders.	Mobility	Same as serial 2.
			Knowledge	
			Survivability	
			Lethality	To an effective range of 2500 m, during day and night and while static and moving, the weapons systems on the vehicle should provide: • Neutralization and destruction of light armoured vehicles and lightly improved static targets. • Neutralization of heavy armoured vehicles and heavily protected static targets.
			Sustainability	Same as serial 2.

Light Capability				
Serial	Vehicle	Description	Capability	Capability Description
2c	Command Support (C3)	Provides a protected vehicle for the conduct of planning, control and coordination of operations.	Mobility	Same as serial 2.
			Knowledge	C3—Configured as a command post with similar capability as serial 2 with more stations/radios.
			Survivability	Same as serial 2.
			Lethality	
			Sustainability	
2d Sensors—ability to detect, identify and jam electromag-netic spectrum	Command Support (EW)	Provides a protected vehicle for the conduct of all aspects electronic warfare.	Mobility	Same as serial 2.
			Knowledge	C3—Ability to fuse data from integral sensors with those available throughout the FFCV. Sensors—Ability to detect, identify and jam electromagnetic spectrum.
			Survivability	Same as serial 2.
			Lethality	
			Sustainability	
2e Sensors—enhanced CBRN detectors, EO/IR sensor, laser designator, deployable recce/surv UGV, platoon-level UAV Neutralization of heavy armoured vehicles and heavily protected static targets	Reconnaissance	Provides a protected vehicle for the conduct of primarily mounted reconnaissance.	Mobility	Same as serial 2.
			Knowledge	C3—Ability to fuse data from integral sensors with those available throughout the FFCV. Sensors—Enhanced CBRN detectors, EO/IR sensor, laser designator, deployable recce/surv UGV, platoon-level UAV.
			Survivability	Same as serial 2.
			Lethality	Neutralization and destruction of light armoured vehicles and lightly improved static targets. Neutralization of heavy armoured vehicles and heavily protected static targets.
			Sustainability	Same as serial 2.

Light Capability				
Serial	Vehicle	Description	Capability	Capability Description
2f Sensors—ground surveillance radar, weapons locating sensors, EO/IR sensor, laser designator, capable of controlling bn and higher-level UAVs	Surveillance	Provides a protected vehicle for the conduct of primarily mounted surveillance of the battlefield.	Mobility	Same as serial 2.
			Knowledge	C3—Ability to fuse data from integral sensors, both vehicle mounted and dismountable, with those available throughout the FFCV. Sensors—Enhanced CBRN detectors, EO/IR sensor, laser designator, deployable recce/surv UGV, platoon-level UAV.
			Survivability	Same as serial 2.
			Lethality	
			Sustainability	
2g	Multi-role Cbt System	Provides a protected vehicle that can provide line-of-sight and beyond-line-of sight firepower support plus a mounted combat capability.	Mobility	Same as serial 2.
			Knowledge	
			Survivability	
			Lethality	Neutralization and destruction of light armoured vehicles and lightly improved static targets. Neutralization of heavy armoured vehicles and heavily protected static targets.
			Sustainability	Same as serial 2.
2h Sensors—either onboard or direct links to sensors capable of detecting and tracking multiple rockets, artillery and mortar shells and air assets	Munitions Defence	Provide a protected vehicle to point protection against rocket, artillery, mortar and limited air attack.	Mobility	Same as serial 2.
			Knowledge	C3—A fire control system capable of automatically prioritizing and engaging targets. Sensors—Either onboard or direct links to sensors capable of detecting and tracking multiple rockets, artillery and mortar shells and air assets.
			Survivability	Same as serial 2.
			Lethality	Weapon system optimized to destroy multiple incoming rockets, artillery and mortar shells and air assets.
			Sustainability	Same as serial 2.
2i	Engineer Manoeuvre Support	Provides a manoeuvre capability for an engineer section.	Mobility	Tactical—Provide tactical mobility and counter-mobility support.
			Knowledge	Same as serial 2.
			Survivability	
			Lethality	
			Sustainability	

Light Capability				
Serial	Vehicle	Description	Capability	Capability Description
2j	General Purpose	Provides a protected transport capability to individuals and teams for miscellaneous tasks (e.g., gun tractor).	Mobility	Same as serial 2.
			Knowledge	
			Survivability	
			Lethality	
			Sustainability	
2k	Medium Recovery	Provides mobility and protection for the recovery of light and medium vehicles.	Mobility	Tactical—Provide tactical recovery support.
			Knowledge	Same as serial 2.
			Survivability	
			Lethality	
			Sustainability	
2l	Mobile Repair	Provides mobility and protection to a mobile repair capability.	Mobility	Same as serial 2.
			Knowledge	
			Survivability	
			Lethality	
			Sustainability	
2m	CASEVAC	Provides a protected vehicle to conduct casualty evacuation.	Mobility	Same as serial 2.
			Knowledge	
			Survivability	
			Lethality	
			Sustainability	
2n	Trauma	Provides a protected vehicle for the forward conduct of medical services.	Mobility	Same as serial 2.
			Knowledge	
			Survivability	
			Lethality	
			Sustainability	

Light Capability				
Serial	Vehicle	Description	Capability	Capability Description
3	Heavy Vehicle	This vehicle provides greater lethality and protection against direct, indirect and IED attack then the medium capability.	Mobility	Strategic—C17, ship transportable. Operational—Road, rail. Tactical—Enhance on/off road.
			Knowledge	C3—Networked C2 and situational awareness. Sensors—EO and IR weapons sight, basic level of CBRN detection.
			Survivability	Signature—Lower signature levels across all spectrums when compared with legacy systems. Active protection—Defensive aid suite to defeat guided and unguided kinetic threats. Passive protection—Integral, scaleable passive protection capable of stopping 105 mm round at 1000 m that can be mounted and dismounted using tools and equipment located at second-line CSS units. Behind armour effects—Multiple, redundant mitigation measures for the protection of crewmembers. Repair—Forward, rapid repair of attack damage and isolation of other systems from secondary damage.

Light Capability				
Serial	Vehicle	Description	Capability	Capability Description
			Lethality	To an effective range of 1200 m, during day and night and while static and moving, the weapons systems on the vehicle should provide: • Neutralization and destruction of dismounted troops, unprotected transport vehicles, light vehicles, unimproved static targets. • Neutralization of light armoured vehicles and lightly protected static targets. • Coordination and direction of FFCV integral firepower. • Coordination and direction of joint/ coalition firepower.
			Sustainability	Optimize the level of component commonality within the class. Use of novel technologies to reduce fuel consumption in comparison with legacy systems.
3a	Mtd Cbt and LOS Fire Support	Provides direct fire at line-of-sight ranges while providing protection for the crew against tank and missile munitions.	Mobility	Same as serial 3.
			Knowledge	
			Survivability	
			Lethality	To an effective range of 4000 m, during day and night and while static and moving, the weapons systems on the vehicle should provide: • Neutralization and destruction of light armoured vehicles, heavy armoured vehicles, lightly improved static targets and heavily protected static targets.
			Sustainability	Same as serial 3.

Light Capability				
Serial	Vehicle	Description	Capability	Capability Description
3b Neutralization and destruction of light armoured vehicles, heavy armoured vehicles, lightly improved static targets and heavily protected static targets	Manoeuvre	Provides a manoeuvre capability for an infantry section.	Mobility	Same as serial 3.
			Knowledge	
			Survivability	
			Lethality	To an effective range of 2500 m, during day and night and while static and moving, the weapons systems on the vehicle should provide: • Neutralization and destruction of light armoured vehicles, heavy armoured vehicles, lightly improved static targets and heavily protected static targets.
			Sustainability	Same as serial 3.
3c	Engineer Gap Support	Provides a protected gap crossing capability for all other classes of FFCV.	Mobility	Tactical—Provide gap crossing capability up to 18 m for all weights of vehicles.
			Knowledge	Same as serial 3.
			Survivability	
			Lethality	
			Sustainability	
3d Tactical—provide obstacle breaching capability	Engineer Breach Support	Provides a protected vehicle for the conduct of obstacle breaching operations.	Mobility	Same as serial 3, and: Tactical—Provide gap crossing capability up to 18 m for all weights of vehicles.
			Knowledge	Same as serial 3.
			Survivability	
			Lethality	
			Sustainability	
3e	Heavy Recovery	Provides mobility and protection for the recovery of up to and including heavy vehicles.	Mobility	Tactical—Provide tactical recovery support.
			Knowledge	Same as serial 3
			Survivability	
			Lethality	
			Sustainability	

Light Capability				
Serial	Vehicle	Description	Capability	Capability Description
4	NLOS Fire Support	Provides a system for non-line-of-sight gun and rocket fire support.	Mobility	Strategic—C17, ship transportable. Operational—Road, rail. Tactical—Enhance on/off road.
			Knowledge	C3—Networked C2 and situational awareness. Sensors—EO and IR weapons sight, basic level of CBRN detection.
			Survivability	Signature—Lower signature levels across all spectrums when compared with legacy systems. Active protection—Defensive aid suite to defeat guided and unguided kinetic threats. Passive protection—Integral, scaleable passive protection capable of stopping 14.5 mm round at 500 m that can be mounted and dismounted using tools and equipment located at second-line CSS units. Behind armour effects—Multiple redundant mitigation measures for the protection of crewmembers. Repair—Forward, rapid repair of attack damage and isolation of other systems from secondary damage.
			Lethality	Neutralization and destruction of dismounted troops, unprotected transport vehicles, light vehicles and unimproved static targets. Neutralization light armoured vehicles and lightly protected static targets.
			Sustainability	Use of novel technologies to reduce fuel consumption.
4a	NLOS—Rocket	Provides a system to conduct non-line-of-sight rocket precision and area fire support.	Mobility	Same as serial 4.
			Knowledge	C3—Integrated into joint and coalition fires network.
			Survivability	Same as serial 4.
			Lethality	
			Sustainability	

Light Capability				
Serial	Vehicle	Description	Capability	Capability Description
4a	NLOS—Gun	Provides a system to conduct non-line-of-sight gun precision and area fire support.	Mobility	Same as serial 4.
			Knowledge	C3—Integrated into joint and coalition fires network.
			Survivability	Same as serial 4.
			Lethality	Long-range neutralization and destruction of all target types.
			Sustainability	Same as serial 4.
5	Support Vehicle/ Cargo	Provides a vehicle to conduct resupply of sub-units and sub-sub-units. May come with various loading/off-loading capabilities.	Mobility	
			Knowledge	
			Survivability	
			Lethality	
			Sustainability	
5a	Medium Support Vehicle	Provides lift of up to 18 Tonnes of cargo.		
5b	Heavy Support Vehicle	Provides lift of up to 36 Tonnes of cargo.		
6	Unmanned Air Vehicle Class	Provides a platform for aerial reconnaissance, target acquisition and possibly target designation.	Mobility	Strategic—Dependant upon variant. Operational—Dependant upon variant. Tactical—Dependant upon variant.
			Knowledge	C3—Networked into C2 and situational awareness. Sensors—EO and IR camera.
			Survivability	Signature—Lower signature levels across all spectrums when compared with legacy systems. Active protection—Nil. Passive protection—Little. Behind armour effects—Nil. Repair—Forward, rapid repair of attack damage and isolation of other systems from secondary damage.
			Lethality	Dependant upon variant.
			Sustainability	Optimize the level of component commonality within the class. Use of novel technologies to reduce fuel consumption in comparison with legacy systems

Light Capability				
Serial	Vehicle	Description	Capability	Capability Description
6a	UAV Level 1	Provides a platform for aerial reconnaissance, target acquisition, target designation and target engagement. Controlled at bn level. It requires a dedicated crew to launch, control and maintain.	Mobility	Strategic—C17 transportable due to launch, repair and control vehicle requirements. Operational—Driven or transported by flatbed. Tactical—Air vehicle operates with 500 km radius at 16000 ft mean sea level (MSL).
			Knowledge	Sensors—Synthetic aperture radar, laser designator.
			Survivability	Same as serial 6.
			Lethality	Armed with anti-armour missiles. Capable of designating target for other precision munitions delivery systems.
			Sustainability	Same as serial 6.
6b	UAV Level 2	Provides a platform for aerial reconnaissance and target acquisition to provide over-the-hill capabilities in a hand/soldier launched platform. It requires a trained person to launch, control and maintain.	Mobility	Strategic—Full kit fits in containers, carried as cargo. Operational—Carried in vehicle or on helo. Tactical—Air vehicle operates with 50 km radius at 15000 ft MSL.
			Knowledge	Same as serial 6
			Survivability	
			Lethality	
			Sustainability	
6c	UAV Level 3	Provides a platform for aerial reconnaissance and target acquisition to provide around-the-corner capabilities. It is disposable and does not require trained personnel to launch, control and maintain.	Mobility	Strategic—Full kit fits in containers, carried as cargo. Operational—Carried in vehicle or on helo. Tactical—Air vehicle operates with 6 km radius at 10000 ft MSL, is hover capable.
			Knowledge	Same as serial 6.
			Survivability	
			Lethality	
			Sustainability	

Light Capability				
Serial	Vehicle	Description	Capability	Capability Description
7	Unmanned Ground Vehicle	A platform that can operate either under direct control, semi-autonomously or autonomously that can be fitted with various cargo as described below.	Mobility	Strategic—C17, ship transportable. Operational—Road, rail, heavy helo, STOL, slung helicopter. Tactical—Enhance on/off road.
			Knowledge	C3—Networked into C2 and situational awareness. Sensors—EO and IR camera for semi-autonomous and autonomous operation.
			Survivability	Signature—Lower signature levels across all spectrums when compared with legacy systems. Active protection—Nil. Passive protection—Little. Behind armour effects—N/A. Repair—Forward, rapid repair of attack damage and isolation of other systems from secondary damage.
			Lethality	Dependant upon variant.
			Sustainability	Optimize the level of component commonality within the class. Use of novel technologies to reduce fuel consumption in comparison with legacy systems.
7a	UGV Recce-Surveil-lance	Provides the soldier with a platform that can semi-autono-mously or autonomously provide sensor information in areas that may be initially too hazardous for soldiers or larger recce vehicles.	Mobility	Same as serial 7.
			Knowledge	C3—Sensors integrated in C2 and SA network. Sensors—EO/IR camera, laser designator
			Survivability	Same as serial 7.
			Lethality	Can designate targets for integral or joint/combined fire support assets.
			Sustainability	Same as serial 7.

Light Capability				
Serial	Vehicle	Description	Capability	Capability Description
7b	UGV Assault	Provides the dismounted section with a platform that follows them on the battlefield and can be used as a short-range direct or indirect fire capability (close air support weapon (CASW)-like capability).	Mobility	Same as serial 7.
			Knowledge	C3—Sensors integrated in C2 and SA network. Sensors—EO/IR camera, laser designator.
			Survivability	Same as serial 7.
			Lethality	Neutralization and destruction of dismounted troops, unprotected transport vehicles, light vehicles and unimproved static targets. Neutralization of light armoured vehicles and lightly protected static targets.
			Sustainability	Same as serial 7.
7c Sensors—detect mines/IEDs to a depth >30 cm, marks mine location	UGV Counter Explosive Hazard	Provides the dismounted soldier with an explosive hazard detection and defeat capability.	Mobility	Same as serial 7.
			Knowledge	C3—Sensors integrated in C2 and SA network. Sensors—Detect mines/IEDs to a depth >30 cm, marks mine location.
			Survivability	Same as serial 7.
			Lethality	Nil.
			Sustainability	Same as serial 7.
7d	UGV CSS	Provides the dismounted section with a “mule” to deliver and/or carry combat supplies to sections and/or individual soldiers.	Mobility	Same as serial 7.
			Knowledge	
			Survivability	
			Lethality	Nil.
			Sustainability	Same as serial 7.

Annex B to Chapter 6
FFCV Fundamental Investigation of Defence Objective Scoring

Following the March 2007 Army Capability Development Board (ACDB), direction was given to make the FFCV study more useful for senior decision-makers by indicating preliminary investment recommendations based upon a rigorous examination of the vehicle options against a set of criteria. Given the multi-dimensional nature of this problem—with its multiple options, multiple criteria and multiple subject matter experts—the operations research tool FIDO was selected for use.

The Fundamental Investigation of Defence Objectives (FIDO) tool has been developed to allow a group of experts to prioritize a set of options against multiple criteria. The tool is based on "value-focused thinking"[287] and endeavours to produce insights, promote creativity and produce an audit trail using a representative group of informed experts to evaluate options against agreed fundamental criteria.

A successful FIDO exercise demands careful consideration of the ranking criteria. As such, criteria must be selected in a manner that is both collectively exhaustive and mutually exclusive within the context of the problem's objectives. In this context, FIDO incorporates two types of evaluation criteria: benefit and risk criteria. The tool allows for a maximum of 60 benefit criteria (user defined) and two risk criteria, in this case, "operational risk" and "technical feasibility." A more generic name for the "operational risk" criterion is "operational impact," and a more generic name for the "technical feasibility" criterion is "implementation likelihood."

An option exists within FIDO to enter the cost ($M) for each option, which the tool utilizes to determine the value for cost ranking of the options. The costs of projects are usually taken from the Capability Initiative Database (CID), but given the conceptual state of this exercise, it was not feasible to use actual costs, which should have reflected total life cycle costs. As an alternative, projects were rank-ordered from most to least expensive based upon the best judgement of participating subject matter experts. It must be acknowledged that this compromise method does not adequately reflect the magnitude of possible cost variance between the most and least expensive options. Furthermore, caution must be exercised in utilizing this ranking information given the unfamiliarity of many of the participants with military vehicle costing information.

Given the aforementioned requirements for conducting a successful FIDO exercise and current DLCD guidance, the following benefit criteria were utilized:

a. **Current Operational Requirement (COR)**. Vehicle options were placed in rank order from 1 to 32, where position 1 is the vehicle that provides the best combination of attributes/capabilities that address the current challenges (mobility, firepower, protection, sustainability, system-level integration, networking) of the contemporary operating environment (COE), e.g., Op ATHENA. (See Figure 6B-1 below for group ranking results.)

287 This is a methodology where fundamental values (criteria) are used to evaluate the available options. The values (benefit and risk criteria), however, must sufficiently frame the problem space to be considered.

b. **Adaptive Dispersed Operations**. Vehicle options were placed in rank order from 1 to 32, where position 1 is the vehicle that provides the best combination of attributes/capabilities that facilitate the implementation of the Land Ops 2021 Concept of ADO, i.e., leading edge capabilities that provide enhanced mobility, survivability, interoperability, modularity and component commonality. Note that since the predicted consequences of the future security environment (FSE) are integral to the Land Ops 2021 FEC, and in keeping with the requirement for criteria to be mutually exclusive, the FSE was not included as a separate benefit criteria. (See Figure 6B-2 below for group ranking results.)

c. **Strategic Future Adaptability**. Vehicle options were placed in rank order from 1 to 32, where position 1 is the vehicle that provides the most significant leap in force innovation and offers the greatest evolutionary modernization potential. (See Figure 6B-3 below for group ranking results.)

d. **Force Projection**. Vehicle options were placed in rank order from 1 to 32, where position 1 is the vehicle that provides the best combination of attributes/capabilities that will facilitate deployability (i.e., designed for rapid sea and air transport) and can be employed in most potential theatres, with the smallest logistic footprint. (See Figure 6B-4 below for group ranking results.

The consolidated rankings from each evaluator and for each of the benefit criteria noted above was aggregated into a single benefit ranking in accordance with the weights assigned to each benefit criterion. Weighting values utilized for the final results, displayed in Figure 6B-5 below, were as follows:

- Current Operational Requirement.....0.2
- Adaptive Dispersed Operations.....0.4
- Strategic Future Adaptability.....0.3
- Force Projection.....0.1

In addition to the benefit criteria noted above, the risk criteria that were used (operational impact and implementation likelihood) are detailed below:

a. Operational Risk. This refers to the potential risk that the Army will not be able to complete its assigned tasks or missions if it is unable or unwilling to implement a particular vehicle project. Higher ranked items reflect higher operational impact, i.e., a platform with a rank of 1 has the greatest operational importance or potential for implementation disruption. (See Figure 6B-6 below for group ranking results.)

b. The rank for this risk criterion is a function of the product of the probability and the consequence of occurrence, as itemized below (a probability of 10 and a consequence of 10 will yield a rank of 1, indicating the item with the greatest operational risk):

Probability:

(a) Evaluates the amount of time remaining in a current (to be replaced) vehicle/platform's service life or the degree to which a new platform (for which there is no in-service platform being replaced) deviates from or extends current operational doctrine, i.e., this is an assessment of the extent of the operational and/or organizational restructuring required to effectively implement the given new platform. Uses a 10-point scale.

(b) Values within the range 1 to 10 are subjectively assigned in accordance with these guidelines:

i. A value of 1 indicates that a current in-service vehicle/platform has 15 or more years remaining in its design service life. Alternatively, the underlying operational concepts for a new platform (not currently fielded) are currently mature or are maturing rapidly within the commercial sector or within allied armies. These concepts are expected to cause only minor organizational upheaval and will mature with minimal experimental effort.

ii. A value of 5 indicates that a current in-service vehicle/platform has 10 years remaining in its design service life. Alternatively, the underlying operational concepts for a new platform are a moderate departure from the current situation and are maturing slowly. These concepts are expected to cause moderate organizational upheaval and will require moderate experimental effort to optimize.

iii. A value of 10 indicates that a current in-service vehicle/platform has less than 5 years remaining in its design service life. Alternatively, the underlying operational concepts for a new platform are an extensive departure from the current situation and are facing resistance within industry or other allied armies. These concepts are expected to cause significant organizational upheaval and will require extensive experimental effort to fully define and optimize.

Consequence:

(a) Evaluates the consequences or operational impact of not procuring a given vehicle/platform upon Army tasks and missions. It also considers the operational interdependency or extent to which the assessed platform requires the integration of other platforms as part of an operational system. Uses a 10-point scale.

(b) Values within the range 1 to 10 are subjectively assigned in accordance with these guidelines:

i. A value of 1 indicates that the Army will be able to conduct all of its future tasks and missions with only slightly degraded performance without this vehicle/platform. Operationally, other platforms have little or no operational reliance/dependency upon the assessed platform.

ii. A value of 5 indicates that the Army will be somewhat restricted in the types of tasks and missions that can be undertaken, i.e., full-spectrum capability is compromised. Operationally, several other platforms rely/depend extensively upon the assessed platform.

iii. A value of 10 indicates that the Army will be unable to conduct many, if not most of its forecasted full-spectrum tasks and missions. Operationally, there is extensive reliance/dependence on the assessed platform/vehicle by all, or most, other platforms.

c. Technological Feasibility. This refers to the risk that the enabling technologies would not be sufficiently mature to fully implement a given vehicle system, i.e., this measures technical or project feasibility or likelihood for success. Higher ranked items reflect a higher likelihood of project failure, i.e., a platform with a rank of 1 is least likely to be easily implemented due to the lack of mature of off-the-shelf technology options or complex project integration issues. (See Figure 6B-7 below for group ranking results.)

d. The rank for this risk criterion is a function of the product of the probability and the consequence of occurrence as itemized below (a probability of 10 and a consequence of 10 will yield a rank of 1, indicating the item with the greatest technical risk):

Probability

(a) Evaluates the maturity of the underlying (enabling) technologies. Uses a 10-point scale.

(b) Values within the range 1 to 10 are subjectively assigned in accordance with these guidelines:

i. A value of 1 indicates that the underlying vehicle/platform technologies are currently mature or are maturing rapidly due to extensive investment within the commercial sector or by military allies. These technologies are expected to reach maturity within the next 5 years.

ii. A value of 5 indicates that the underlying technologies have been identified but are maturing modestly due to moderate investment within the commercial sector or by military allies. These technologies are expected to reach maturity within the next 10 years but will require increased focus and expenditure.

iii. A value of 10 indicates that the underlying technologies may have been identified but are stagnant or require new breakthroughs and significant investment. Breakthroughs are expected within 15 years.

Consequence

(a) Evaluates the extent to which technical competency exists within Canadian defence industry to design, integrate and build the respective FFCE vehicles/platforms. Uses a 10-point scale.

(b) Values within the range 1 to 10 are subjectively assigned in accordance with these guidelines:

i. A value of 1 indicates that extensive R&D, design, build, integrate and test experience exists within Canadian industry for the evaluated platform/vehicle and its enabling technologies. Canadian industry may have an off-the-shelf product or well developed prototype available.

ii. A value of 5 indicates that some R&D, design, build, integrate and/or test experience exists within Canadian industry for the evaluated platform/vehicle and its enabling technologies. Canadian industry does not have an off-the-shelf product or well developed prototype available, but an international commercial or allied system or prototype could be easily project managed by Canadian industry.

iii. A value of 10 indicates that very limited R&D, design, build, integrate or test experience exists within Canadian industry for the evaluated platform/vehicle and its enabling technologies. Canadian industry does not have an off-the-shelf product or well developed prototype available, and there would be substantial project implementation risk dealing with an international commercial vendor or allied partner since no valid Canadian industry expertise exists.

Aggregate risk was calculated in a similar fashion to the aggregate benefit ranking. The weighting utilized for calculating the aggregate risk results shown in Figure 6B-8 below are as follows:

- Operational Risk 0.6
- Technical Risk 0.4

A final value ranking, as shown in Figure 6B-9 below, was calculated as a combination of the aggregate benefit results and aggregate risk results, each with equal weighting.

Figure 6B-1: Prioritized Rank Order of FFCV Options Based on the Current Operational Requirement (COR) Evaluation Criteria[288]

Current Operational Requirement		
Prioritized Rank	**Proj ID**	**FFCV Component Options**
1	2a	Medium Vehicle—Manoeuvre
2	2B	Medium Vehicle—Command
3	2f	Medium Vehicle—Surveillance
4	2e	Medium Vehicle—Reconnaissance
5	2c	Medium Vehicle—Command Support (C3)
6	2g	Medium Vehicle—Multi-role Cbt System
7	4b	NLOS Fire Support—Gun
8	2m	Medium Vehicle—CASEVAC
9	2n	Medium Vehicle—Trauma
10	2j	Medium Vehicle—General Purpose
11	5a	Support Vehicle/Cargo—Medium Support Vehicle
12	2i	Medium Vehicle—Engineer Manoeuvre Support
13	1b	Light Vehicle—Reconnaissance
14	3a	Heavy Vehicle—Mtd Cbt and lOS Fire Support
15	3b	Heavy Vehicle—Manoeuvre
16	1a	Light Vehicle—Manoeuvre
17	7c	Unmanned Ground Vehicle—UGV Counter Mine
18	6a	Unmanned Air Vehicle Glass—UAV Level 1
19	6b	Unmanned Air Vehicle Class—UAV Level 2
20	2d	Medium Vehicle—Command Support (EW)
21	2k	Medium Vehicle—Medium Recovery
22	6c	Unmanned Air Vehicle Class—UAV Level 3
23	2l	Medium Vehicle—Mobile Repair
24	5b	Support Vehicle/Cargo—Heavy Support Vehicle
25	3d	Heavy Vehicle—Engineer Breach Support
26	3e	Heavy Vehicle—Heavy Recovery
27	7a	Unmanned Ground Vehicle—UGV Recce-Surveillance
28	2h	Medium Vehicle—Munitions Defence
29	3c	Heavy Vehicle—Engineer Gap Support
30	4a	NLOS Fire Support—Rocket
31	7b	Unmanned Ground Vehicle—UGV Assault
32	7d	Unmanned Ground Vehicle—UGV CSS

288 In other words, the order in which vehicles provides the best combination of attributes/capabilities that address the challenges of the COE.

Figure 6B-2: Prioritized Rank Order of FFCV Options Based on the Adaptive Dispersed Operations (ADO) Evaluation Criteria[289]

Adaptive Dispersed Operations		
Prioritized Rank	**Proj ID**	**FFCV Component Options**
1	2a	Medium Vehicle—Manoeuvre
2	2g	Medium Vehicle—Multi-role Cbt System
3	2b	Medium Vehicle—Command
4	2f	Medium Vehicle—Surveillance
5	1a	Light Vehicle—Manoeuvre
6	1b	Light Vehicle—Reconnaissance
7	2c	Medium Vehicle—Command Support (C3)
8	2e	Medium Vehicle—Reconnaissance
9	2m	Medium Vehicle—CASEVAC
10	4b	NLOS Fire Support—Gun
11	6a	Unmanned Air Vehicle Class—UAV Level 1
12	2j	Medium Vehicle—General Purpose
13	2i	Medium Vehicle—Engineer Manoeuvre Support
14	6b	Unmanned Air Vehicle Class—UAV Level 2
15	6c	Unmanned Air Vehicle Class—UAV Level 3
16	4a	NLOS Fire Support—Rocket
17	7a	Unmanned Ground Vehicle—UGV Recce-Surveillance
18	2n	Medium Vehicle—Trauma
19	7c	Unmanned Ground Vehicle—UGV Counter Mine
20	5a	Support Vehicle/Cargo—Medium Support Vehicle
21	2d	Medium Vehicle—Command Support (EW)
22	2k	Medium Vehicle—Medium Recovery
23	7b	Unmanned Ground Vehicle—UGV Assault
24	7d	Unmanned Ground Vehicle—UGV CSS
25	2l	Medium Vehicle—Mobile Repair
26	2h	Medium Vehicle—Munitions Defence
27	5b	Support Vehicle/Cargo—Heavy Support Vehicle
28	3a	Heavy Vehicle—Mtd Cbt and LOS Fire Support
29	3b	Heavy Vehicle—Manoeuvre
30	3c	Heavy Vehicle—Engineer Gap Support
31	3d	Heavy Vehicle—Engineer Breach Support
32	3e	Heavy Vehicle—Heavy Recovery

289 In other words, vehicle order that provides the best combination of attributes/capabilities that will facilitate the implementation of the Land Ops 2021 Concept of ADO.

Figure 6B-3: Prioritized Rank Order of FFCV Options Based on the Strategic Future Adaptability Evaluation Criteria[290]

Strategic Future Adaptability		
Prioritized Rank	**Proj ID**	**FFCV Component Options**
1	2g	Medium Vehicle—Multi-role Cbt System
2	2a	Medium Vehicle—Manoeuvre
3	2d	Medium Vehicle—Command Support (EW)
4	7a	Unmanned Ground Vehicle—UGV Recce-Surveillance
5	2e	Medium Vehicle—Reconnaissance
6	2f	Medium Vehicle—Surveillance
7	7b	Unmanned Ground Vehicle—UGV Assault
8	6a	Unmanned Air Vehicle class—UAV Level 1
9	7c	Unmanned Ground Vehicle—UGV Counter Mind
10	1b	Light Vehicle— Reconnaissance
11	6b	Unmanned Air Vehicle Class—UAV Level 2
12	6c	Unmanned Air Vehicle Class—UAV Level 3
13	2b	Medium Vehicle—Command
14	2c	Medium Vehicle—Command Support (C3)
15	4b	NLOS Fire Support—Gun
16	7d	Unmanned Ground Vehicle—UGV CSS
17	4a	NLOS Fire Support—Rocket
18	1a	Light Vehicle—Manoeuvre
19	2h	Medium Vehicle—Munitions Defence
20	2m	Medium Vehicle—CASEVAC
21	2n	Medium Vehicle—Trauma
22	2i	Medium Vehicle—Engineer Manoeuvre Support
23	2j	Medium Vehicle—General Purpose
24	5a	Support Vehicle/Cargo—Medium Support Vehicle
25	2k	Medium Vehicle—Medium Recovery
26	2l	Medium Vehicle—Mobile Repair
27	3a	Heavy Vehicle—Mtd Cbt and LOS Fire Support
28	3b	Heavy Vehicle—Manoeuvre
29	3c	Heavy Vehicle—Engineer Gap Support
30	3d	Heavy Vehicle—Engineer Breach Support
31	5b	Support Vehicle/Cargo—Heavy Support Vehicle
32	3e	Heavy Vehicle—Heavy Recovery

290 In other words, vehicle order that provides the most significant leap in force innovation and offers the greatest evolutionary modernization potential.

Figure 6B-4: Prioritized Rank Order of FFCV Options Based on the Force Projection Evaluation Criteria[291]

Force Projection		
Prioritized Rank	**Proj ID**	**FFCV Component Options**
1	1a	Light Vehicle—Manoeuvre
2	1b	Light Vehicle—Reconnaissance
3	2a	Medium Vehicle—Manoeuvre
4	2g	Medium Vehicle—Multi-role Cbt System
5	2b	Medium Vehicle—Command
6	2e	Medium Vehicle—Reconnaissance
7	2f	Medium Vehicle—Surveillance
8	2c	Medium Vehicle—Command Support (C3)
9	4b	NLOS Fire Support—Gun
10	6a	Unmanned Air Vehicle Class—UAV Level 1
11	6b	Unmanned Air Vehicle Class—UAV Level 2
12	7a	Unmanned Ground Vehicle—UGV Recce-Surveillance
13	2d	Medium Vehicle—Command Support (EW)
14	2m	Medium Vehicle—CASEVAC
15	2j	Medium Vehicle—General Purpose
16	2i	Medium Vehicle—Engineer Manoeuvre Support
17	2n	Medium Vehicle—Trauma
18	5a	Support Vehicle/Cargo—Medium Support Vehicle
19	6c	Unmanned Air Vehicle Class—UAV Level 3
20	7b	Unmanned Ground Vehicle—UGV Assault
21	2h	Medium Vehicle—Munitions Defence
22	2k	Medium Vehicle—Medium Recovery
23	2l	Medium Vehicle—Mobile Repair
24	7c	Unmanned Ground Vehicle—UGV Counter Mine
25	4a	NLOS Fire Support—Rocket
26	7d	Unmanned Ground Vehicle—UGV CSS
27	3a	Heavy Vehicle—Mtd Cbt and LOS Fire Support
28	3b	Heavy Vehicle—Manoeuvre
29	5b	Support Vehicle/Cargo—Heavy Support Vehicle
30	3c	Heavy Vehicle—Engineer Gap Support
31	3d	Heavy Vehicle—Engineer Breach Support
32	3e	Heavy Vehicle—Heavy Recovery

291 In other words, vehicle order that provides the best combination of attributes/capabilities that will facilitate deployability (i.e., designed for rapid sea and air transport) and can be employed in most potential theatres, with the smallest logistic footprint.

Figure 6B-5: Prioritized Rank Order of FFCV Options Based on the Aggregation of Benefit Evaluation Criteria[292]

Aggregate Benefit Ranking		
Prioritized Rank	**Proj ID**	**FFCV Component Options**
1	2a	Medium Vehicle—Manoeuvre
2	1b	Light Vehicle—Reconnaissance
3	2g	Medium Vehicle—Multi-role Cbt System
4	2b	Medium Vehicle—Command
5	2e	Medium Vehicle—Reconnaissance
6	2f	Medium Vehicle—Surveillance
7	2c	Medium Vehicle—Command Support (C3)
8	1a	Light Vehicle—Manoeuvre
9	2d	Medium Vehicle—Command Support (EW)
10	2m	Medium Vehicle—CASEVAC
11	4b	NLOS Fire Support—Gun
12	6a	Unmanned Air Vehicle—UAV Level 1
13	6b	Unmanned Air Vehicle Class—UAV Level 2
14	2i	Medium Vehicle—Engineer Manoeuvre Support
15	2j	Medium Vehicle—General Purpose
16	2n	Medium Vehicle—Trauma
17	6c	Unmanned Air Vehicle Class—UAV Level 3
18	4a	NLOS Fire Support—Rocket
19	7a	Unmanned Ground Vehicle—UGV Recce-Surveillance
20	7c	Unmanned Ground Vehicle—UGV Counter Mine
21	2h	Medium Vehicle—Munitions Defence
22	5a	Support Vehicle/Cargo—Medium Support Vehicle
23	2k	Medium Vehicle—Medium Recovery
24	2l	Medium Vehicle—Mobile Repair
25	3a	Heavy Vehicle—Mtd Cbt and LOS Fire Support
26	3b	Heavy Vehicle—Manoeuvre
27	7b	Unmanned Ground Vehicle—UGV Assault
28	7d	Unmanned Ground Vehicle—UGV CSS
29	3c	Heavy Vehicle—Engineer Gap Support
30	3d	Heavy Vehicle—Engineer Breach Support
31	5b	Support Vehicle/Cargo—Heavy Support Vehicle
32	3e	Heavy Vehicle—Heavy Recovery

292 In other words, vehicle order that provides the best combination of attributes/capability to support the weighted benefit criteria.

Figure 6B-6: Prioritized Rank Order of FFCV Options Based on the Operational Risk Evaluation Criteria in Order from Highest Operational Impact[293]

Operational Risk		
Prioritized Rank	**Proj ID**	**FFCV Component Options**
1	2f	Medium Vehicle—Surveillance
2	2g	Medium Vehicle—Multi-role Cbt System
3	2n	Medium Vehicle—Trauma
4	2e	Medium Vehicle—Reconnaissance
5	2h	Medium Vehicle—Munitions Defence
6	2m	Medium Vehicle—CASEVAC
7	7a	Unmanned Ground Vehicle—UGV Recce-Surveillance
8	7b	Unmanned Ground Vehicle—UGV Assault
9	7c	Unmanned Ground Vehicle—UGV Counter Mine
10	4a	NLOS Fire Support—Rocket
11	1b	Light Vehicle—Reconnaissance
12	2a	Medium Vehicle—Manoeuvre
13	2c	Medium Vehicle—Command Support (C3)
14	2d	Medium Vehicle—Command Support (EW)
15	2i	Medium Vehicle—Engineer Manoeuvre Support
16	6a	Unmanned Air Vehicle Class—UAV Level 1
17	6b	Unmanned Air Vehicle Class—UAV Level 2
18	6c	Unmanned Air Vehicle Class—UAV Level 3
19	7d	Unmanned Ground Vehicle—UGV CSS
20	2k	Medium Vehicle—Medium Recovery
21	1a	Light Vehicle—Manoeuvre
22	2b	Medium Vehicle—Command
23	2j	Medium Vehicle—General Purpose
24	2l	Medium Vehicle—Mobile Repair
25	3b	Heavy Vehicle—Manoeuvre
26	3c	Heavy Vehicle—Engineer Gap Support
27	3d	Heavy Vehicle—Engineer Breach Support
28	4b	NLOS Fire Support—Gun
29	5a	Support Vehicle/Cargo—Medium Support Vehicle
30	3a	Heavy Vehicle—Mtd Cbt and LOS Fire Support
31	3e	Heavy Vehicle—Heavy Recovery
32	5b	Support Vehicle/Cargo—Heavy Support Vehicle

293 A platform with a rank of 1 has the greatest operational importance or potential for implementation disruption.

Figure 6B-7: Prioritized Rank Order of FFCV Options Based on the Technical Risk Evaluation Criteria in Order from Higher Likelihood of Project Failure[294]

Technical Risk		
Prioritized Rank	**Proj ID**	**FFCV Component Options**
1	7b	Unmanned Ground Vehicle—UGV Assault
2	7a	Unmanned Ground Vehicle—UGV Recce-Surveillance
3	7c	Unmanned Ground Vehicle—UGV Counter Mine
4	7d	Unmanned Ground Vehicle—UGV CSS
5	2g	Medium Vehicle—Multi-role Cbt System
6	2h	Medium Vehicle—Munitions Defence
7	6c	Unmanned Air Vehicle Class—UAV Level 3
8	4a	NLOS Fire Support—Rocket
9	3a	Heavy Vehicle Mtd Cbt and LOS Fire Support
10	3b	Heavy Vehicle—Manoeuvre
11	4b	NLOS Fire Support—Gun
12	6a	Unmanned Air Vehicle Class—UAV Level 1
13	6b	Unmanned Air Vehicle Class—UAV Level 2
14	1a	Light Vehicle—Manoeuvre
15	1b	Light Vehicle—Reconnaissance
16	2c	Medium Vehicle—Command Support (C3)
17	2d	Medium Vehicle—Command Support (EW)
18	2e	Medium Vehicle—Reconnaissance
19	2f	Medium Vehicle—Surveillance
20	2n	Medium Vehicle—Trauma
21	3c	Heavy Vehicle—Engineer Gap Support
22	3d	Heavy Vehicle—Engineer Breach Support
23	3e	Heavy Vehicle—Heavy Recovery
24	2a	Medium Vehicle—Manoeuvre
25	2b	Medium Vehicle—Command
26	2i	Medium Vehicle—Engineer Manoeuvre Support
27	2j	Medium Vehicle—General Purpose
28	2k	Medium Vehicle—Medium Recovery
29	2l	Medium Vehicle—Mobile Repair
30	2m	Medium Vehicle—CASEVAC
31	5a	Support Vehicle/Cargo—Medium Support Vehicle
32	5b	Support Vehicle/Cargo—Heavy Support Vehicle

294 In other words, a platform with a rank of 1 is least likely to be easily implemented due to the lack of mature off-the-shelf technology options or complex project integration issues.

Figure 6B-8: Prioritized Rank Order of FFCV Options Based on the Aggregation of Risk Evaluation Criteria[295]

Aggregate Risk		
Prioritized Rank	**Proj ID**	**FFCV Component Options**
1	2f	Medium Vehicle—Surveillance
2	2g	Medium Vehicle—Multi-role Cbt System
3	7a	Unmanned Ground Vehicle—UGV Recce-Surveillance
4	7b	Unmanned Ground Vehicle—UGV Assault
5	7c	Unmanned Ground Vehicle—UGV Counter Mine
6	2h	Medium Vehicle—Munitions Defence
7	2n	Medium Vehicle—Trauma
8	4a	NLOS Fire Support—Rocket
9	6b	Unmanned Air Vehicle Class—UAV Level 2
10	6c	Unmanned Air Vehicle Class—UAV Level 3
11	7d	Unmanned Ground Vehicle—UGV CSS
12	2e	Medium Vehicle—Reconnaissance
13	1a	Light Vehicle—Manoeuvre
14	1b	Light Vehicle—Reconnaissance
15	2a	Medium Vehicle—Manoeuvre
16	2b	Medium Vehicle—Command
17	2c	Medium Vehicle—Command Support (C3)
18	2d	Medium Vehicle—Command Support (EW)
19	2i	Medium Vehicle—Engineer Manoeuvre Support
20	2k	Medium Vehicle—Medium Recovery
21	2m	Medium Vehicle—CASEVAC
22	3a	Heavy Vehicle—Mtd Cbt and LOS Fire Support
23	3b	Heavy Vehicle—Manoeuvre
24	3c	Heavy Vehicle—Engineer Gap Support
25	3d	Heavy Vehicle—Engineer Breach Support
26	4b	NLOS Fire Support—Gun
27	6a	Unmanned Air Vehicle Class—UAV Level 1
28	2j	Medium Vehicle—General Purpose
29	2l	Medium Vehicle—Mobile Repair
30	3e	Heavy Vehicle—Heavy Recovery
31	5a	Support Vehicle/Cargo—Medium Support Vehicle
32	5b	Support Vehicle/Cargo—Heavy Support Vehicle

295 In other words, the vehicle order that provides the highest combined operational and technical risk.

Figure 6B-9: Final Prioritized Rank Order of FFCV Options Based on the Aggregation of Benefit and Risk Criteria

Aggregate Value Risk		
Prioritized Rank	**Proj ID**	**FFCV Component Options**
1	2f	Medium Vehicle—Surveillance
2	2g	Medium Vehicle—Multi-role Cbt System
3	7a	Unmanned Ground Vehicle—UGV Recce-Surveillance
4	1b	Light Vehicle—Reconnaissance
5	2a	Medium Vehicle—Manoeuvre
6	2c	Medium Vehicle—Command Support (C3)
7	2e	Medium Vehicle—Reconnaissance
8	1a	Light Vehicle—Manoeuvre
9	2b	Medium Vehicle—Command
10	2d	Medium Vehicle—Command Support (EW)
11	2h	Medium Vehicle—Munitions Defence
12	2m	Medium Vehicle—CASEVAC
13	2n	Medium Vehicle—Trauma
14	4a	NLOS Fire Support—Rocket
15	4b	NLOS Fire Support—Gun
16	6a	Unmanned Air Vehicle Class—UAV Level 1
17	6b	Unmanned Air Vehicle Class—UAV Level 2
18	6c	Unmanned Air Vehicle Class—UAV Level 3
19	7b	Unmanned Ground Vehicle—UGV Assault
20	7c	Unmanned Ground Vehicle—UGV Counter Mine
21	2i	Medium Vehicle—Engineer Manoeuvre Support
22	7d	Unmanned Ground Vehicle—UGV CSS
23	2j	Medium Vehicle—General Purpose
24	5a	Support Vehicle/Cargo—Medium Support Vehicle
25	2k	Medium Vehicle—Medium Recovery
26	2l	Medium Vehicle—Mobile Repair
27	3a	Heavy Vehicle— Mtd Cbt and LOS Fire Support
28	3b	Heavy Vehicle—Manoeuvre
29	3c	Heavy Vehicle—Engineer Gap Support
30	3d	Heavy Vehicle—Engineer Breach Support
31	3e	Heavy Vehicle—Heavy Recovery
32	5b	Support Vehicle/Cargo—Heavy Support Vehicle

Part 3

Capability Requirements

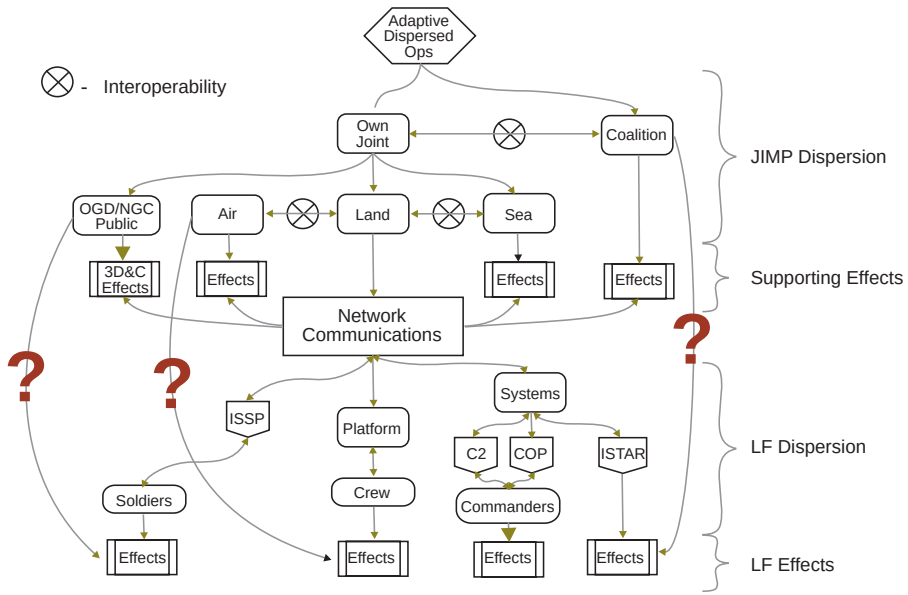
Chapter 7

Networks and Knowledge

By Major Jim Terfry

The future security environment (FSE) compels the Army of Tomorrow (AoT) to adopt a networked approach[296] to full-spectrum operations. A global information system (GIS) will provide the basis for a network architecture that is based around people, procedures and technical infrastructure. This will enable the Army to "plug and play" with its modular forces and provide it with the ability to achieve situational understanding through a common operating picture (COP). The result will be a networked, interdependent force capable of conducting simultaneous, possibly self-synchronized operations in a non-contiguous battlespace and capable of responding instantly to calls for effects.

Figure 7-1: Graphic Representation of a "Networked" AoT



296 The networked approach is closely associated with the concept of network-enabled operations (NEOps), which in itself is essentially a derivative of the concept of network centric warfare (NCW), and is aimed at more fully capturing both the means through which networking could occur as well as the scope of action to which such operations could apply. More specifically, it is intended to correct a *perceived tendency* inherent in *some* treatments of NCW to focus excessively on combat and on the technological aspects of networking. Indeed, the term NEOps attempts to underline the fact that networking can *also* apply to operations other than war, thus the emphasis on contribution to full-spectrum operations, and involves humans as well as a technology. Beyond such differences in emphasis, however, the two terms exhibit considerable similarity. In fact, a widely cited definition of NCW continues to offer a good summation. Specifically, NCW is "…an information superiority enabled concept that generates increased combat power by networking sensors, decision makers, and shooters to achieve shared awareness, increased speed of command, higher tempo of operations, greater lethality, increased survivability, and a degree of self-synchronization." See David S. Alberts, John J. Garstka and Fredrick P. Stein, *Network Centric Warfare: Developing and Leveraging Information Superiority* (Washington, DC: DoD Command and Control Research Program, 2003), p. 2.

The network will not change the enduring nature of operations. It will, however, offer new opportunities, primarily through more rapid information exploitation, to achieve heightened situational awareness, greater agility and superior operational tempo. Key to an effective network is the willingness to exchange information. In the 2020 timeframe, the AoT will aspire to seamlessly share data in a joint, interagency, multinational and public (JIMP) environment.

While the network will provide the AoT with significant advantages, an adversary may seek not only to destroy or degrade the AoT's networks but to exploit them for their own information operations. The advantages of the network will also be challenged by complex terrain. Accordingly, efforts to ensure the creation of redundancies as well as fail-safe and fallback mechanisms and procedures within the network must be an integral component of its development.

As a minimum level of capability, the AoT must have a timely and accurate common operating picture (COP) in support of increased situational awareness and understanding. Collaborative planning and C4ISTAR[297] are essential elements of the network and should be accessible by all tactical elements. The AoT will also need to have well-established procedures for information sharing with non-alliance, non-ABCA (America, Britain, Canada and Australia) and other JIMP partners.

Complementary attributes of an effective future network include:

- Improved sensors, data fusion, communications and knowledge management networking leading to higher levels of information sharing and management, enabling more effective application of effects, decentralization, and non-contiguous operations.

- Improvements in command capabilities and staff processes so as to increase opportunities for information/decision superiority and improved anticipatory planning (to permit continuous assessment and enable better decision-making).

- Advances in ISTAR, and precision, to allow for engagements at greater ranges, with greater effects, and for more rapid tactical decision-making—a benefit which will, in turn, permit tactical units to transition, without pausing, to subsequent engagements.

- Advances in C4, ISTAR, stealth and mobility to enable transition to a force protection and survivability model no longer as dependent on heavy armour and passive protection as that which characterizes existing mechanized forces.

- Systems and procedures that guard against network paralysis, and sufficient organic capabilities to allow tactical elements to live, move and fight autonomously until they are reinforced or while disrupted networks are re-established.

297 Command, control, communications, computers, intelligence, surveillance, target acquisition and reconnaissance (C4ISTAR). This would include intelligence collection, dissemination; decision superiority, data processing, fusion, integrated collection, global information system (GIS) and common data protocols.

Network-enabled Operations

Along with the AoT soldier, the network is arguably the critical enabler, the one key component which land operations in the 2021 timeframe must have in order to conduct full-spectrum operations. The network, and the military advantages that the effective integration of information systems (both technological and human) can produce through the creation and exploitation of information, facilitates network-enabled operations (NEOps). According to its proponents, NEOps represents an effective military response to the challenges and the opportunities created by the information age. By linking knowledgeable entities in the battlespace, forces will be more capable of gaining information superiority and, ultimately, greater military effectiveness.

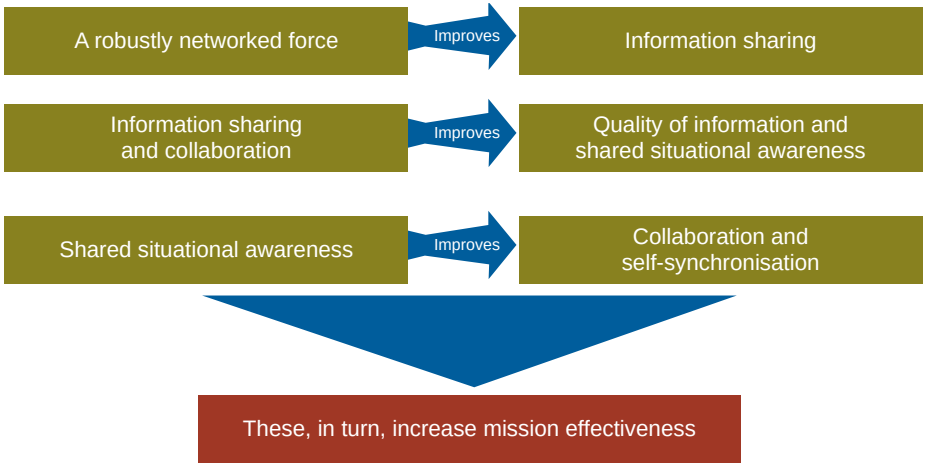
The concept relies heavily on an appropriate integration of both technological and human capital. On the one hand, it presumes acquisition of a myriad of computer networking and information-sharing technologies and capabilities to facilitate effective storage as well as fast processing and distribution of key information. On the other, it requires possession of a range of human cognitive and behavioural skills as well as organizational procedures and arrangements capable of ensuring that the information gained through the exploitation of enhanced technologies can be effectively harnessed to support key policy aims and objectives.[298]

Such networking would create the ability to achieve shared and near real-time situational awareness (SA). Accordingly, effects in the battle space would be better synchronized, speed of command would be increased, and the lethality, survivability and responsiveness of forces would improve immeasurably.[299] The result would be a capacity to conduct a more precise, agile style of manoeuvre warfare, in which armed forces could conceivably engage in near-continuous action. Not only would the capacity to more effectively and efficiently defeat enemy forces increase but, ultimately, the ability to engage in actions capable of breaking an adversary's will while leaving the majority of his forces intact would do so as well.

298 NEOps could involve: (1) the use of networking technologies to facilitate the improved execution of existing military plans, doctrines and tactics; (2) the development of new plans, doctrine and tactics so as to better exploit the possibilities inherent in technology; and, ultimately, (3) the application of new technologies and thinking to develop a new style and practice of combat. In a NEOps'd military, forces would not only perform existing operations better (quicker, more efficiently and effectively) but possibly undertake missions that could not be attempted if such capabilities had not existed. See Edward R. Smith, *Effects Based Operations: Applying Network Centric Warfare in Peace, Crisis and War* (Washington, DC: DoD Command and Control Research Program, July 2003), pp. 65–97.

299 The concept rests on four basic tenets or assumptions: that a robustly networked force will improve information sharing; that information sharing will enhance the quality of information and shared situational awareness available; that shared situational awareness will enable collaboration and self-synchronization and will enhance sustainability and speed of command; and that these, in turn, will dramatically increase mission effectiveness. Such networking, moreover, would occur across all four domains of warfare—the physical, information, social and cognitive domains. For further elaboration, see, David S. Alberts, John J. Garstka and Fredrick P. Stein, *Network Centric Warfare: Developing and Leveraging Information Superiority* (Washington, DC: DoD Command and Control Research Program, 2003), pp. 88–93.

Figure 7-2: The Posited Benefits of Network-Enabled Processes



In fact, by offering a more efficient means for forces to affect the behaviour of intended targets, NEOps would provide an important enabler for conducting effects based operations (EBO), i.e., coordinated sets of actions aimed at shaping the behaviour of intended targets (e.g. friends, allies, neutrals and foes in peace, crisis and war).[300] Simply put, NEOps would constitute an important means through which EBO could be achieved.

Risks

Implementation of such a vision could nevertheless face considerable challenges. In addition to the acquisition of requisite technologies, policy-makers face a range of issues regarding their integration, management and utilization.

The establishment of data standards, procedures ensuring greater interoperability of networks, and the standardization of processes for information handling, from sensors and information to decision-makers and effectors, would all be essential. Policy and procedures would need to be revised, both to facilitate movement of information and access internally as well as with foreign counterparts. And personnel would require thorough education and training not only in becoming more technologically adept (i.e., human-machine interface) but also more effective in the collection, transfer and analysis of information within and between organizations.

Beyond this, the concept could involve the development of doctrinal and organizational concepts and command doctrines better suited to exploiting the potential that a physically networked force could provide. In essence, NEOps would demand that institutions and organizations shift in effect from “a need to know” to “a willingness to share” culture. In order to take full advantage of a network-enabled force, the chain of command would at times be less hierarchical in character, control more indirect and interoperability more all-encompass-

300 See Edward R. Smith, *Effects Based Operations: Applying Network Centric Warfare in Peace, Crisis and War* (Washington, DC: DoD Command and Control Research Program, July 2003), p. 108.

ing than is currently the case. And as capacities for enhanced information sharing and analysis matured and became institutionalized, demands for other changes could well follow.

The economic, technological, institutional and cultural challenges involved in bringing about such changes are thus likely to be considerable. Land forces could face a particularly stiff challenge. Indeed, the sheer number of nodes that would require networking (e.g., soldiers and family of future combat vehicles [FFCV] platforms), along with the need to ensure robust, reliable operation of the network even under the most complex and harsh circumstances (ground combat, peace support operations), would demand a high level of effort and commitment.

Notably, in those cases in which networked ground forces have been fielded, technical limitations on bandwidth have already been evident.

Problems could also extend beyond realization of a technologically networked force to its use. Alongside promises that the information superiority and enhanced situational awareness would result in dramatically improved military effectiveness and efficiency linger concerns over possibilities of information overload, inappropriate information sharing and chronic micro-management. Should such difficulties materialize, fast decision-making and seamless execution of missions and tasks could easily be replaced by widespread confusion, gridlock and frustration.[301]

Opportunities

Still, the burdens and risks of foregoing exploration of a network-enabled capability could well exceed those associated with its adoption. Potential dangers notwithstanding, even tentative evidence of the utility of NEOps is difficult to ignore. And the fact that such evidence has already generated considerable interest in more technologically networked forces within the military establishments of a number of important allied countries makes the case for exploration all the more compelling.[302] At the very least, it suggests that NEOps may not only yield benefits, but that a good number of obstacles might well be avoided if such a capability is pursued with caution and foresight.[303]

Perhaps most significant to the pursuit of NEOps is the fact that Army experience with networking is both deeper and more complex than generally acknowledged. The very nature of land force operations has long involved networking, with mission success typically dependent on the ability of many soldiers to act both as individual units of data processing

301 Criticism of network-centric thinking is plentiful. For particularly insightful critiques, see Thomas P.M. Barnett, "The Seven Deadly Sins of Network-Centric Warfare," *US Naval Institute Proceedings* Vol. 125, No. 1 (January 1999), pp. 36–39; Aldo Borgu, "The Challenges and Limitations of 'Network Centric Warfare': The Initial Views of an NCW Sceptic," *Australian Strategic Policy Institute* (September 2003); L. Col. H.R. McMaster, *Crack in the Foundation: Defense Transformation and the Underlying Assumption of Dominant Knowledge in Future War* (Center for Strategic Leadership, United States Army War College, November 2003); and Fredrick W. Kagan, "War and Aftermath," *Policy Review*, No. 120 (August and September 2003).

302 For a useful overview of the efforts of a number of European countries, see Stefan Nitschke, "Network-Centric Warfare—The European Initiatives," *Military Technology*, 3/2004, pp. 18-26.

303 In this regard, it should be noted that many of the risks and dangers cited as attending the development of NEOps fall in the realm of the *potential* as opposed to the *inevitable*. In fact, to the extent that such critiques are heeded, it is possible that many of the red flags they raise can be avoided.

and action (i.e., nodes, sensors and shooters) as well as collectively to achieve a desired end state (as defined by the commander) in the best manner possible.

In the case of Canada's Army, longstanding responsibilities and demands have generated a training regime and mindset at the individual soldier level strongly informed by many of the qualities and skills that NEOps requires and must foster to be successful. In this regard, skills such as effective verbal and non-verbal communication and coordination, information processing and analysis, and timely decision-making are already key aspects of soldier development.

Particularly important is the presence of an organizational milieu conducive to the development of trust, initiative and critical problem solving—qualities that are crucial to the development and effective utilization of a more networked force. In this regard, a strong spirit of egalitarianism along with the Canadian Army's philosophy of mission command are key. Both work to encourage more decentralized decision-making and with it the development among soldiers of a wider, more strategic view of operations and missions. Soldiers are thus better able to consider the broader implications of actions taken in the field. The fact that Canadian Army command philosophy further stresses uncertainty and surprise as inevitable aspects of warfare and the need to cultivate an ability to undertake decisive action within such an environment offers an additional benefit. Indeed, this should serve as an important caution against any tendencies to develop of excessive reliance on the information that any network would provide, underlining the fact that while technology may well reduce the fog and friction of war, it will never eliminate them entirely.

Toward The Network

Fashioning an approach to NEOps that manages the challenges associated with its pursuit minimizes the risks which it poses and effectively harnesses the networking assets which the Canadian Army *already* possesses, nevertheless, remains a difficult task. It is particularly daunting in light of the fact that despite considerable interest and increasing experimentation and application of networking concepts and technologies within various militaries, no clear examples of a *fully* networked force currently exist.

Still, recognition of *both* the challenges and opportunities associated with networks and NEOps suggests that pursuit of such a strategy must be gradual and tightly focused. To this end, efforts should concentrate attention primarily, although by no means exclusively, on the social-psychological, i.e., "wetware," aspects of the equation. In particular, the Army of Tomorrow approach must be informed by an appreciation of the fact that, ultimately, NEOps is less about technology per se than it is about fostering certain habits of mind, social behaviours and decision-making skills to better facilitate the realization of military objectives.

Should excessive faith be placed in technology, not only are the economic, technical and institutional–cultural barriers to progress likely to be excessive but the risks might well be also. Indeed, such a strategy could even work to nullify much of the Army's already solid capacities pertaining to the human dimensions of networking. The result could well be an overall decline in networking capacity and, ultimately, in military effectiveness.

Consequently, it is recommended that the Army of Tomorrow build on the cognitive and social assets that are essential to an effectively networked force. It is suggested that development and acquisition of networking technologies should proceed, first and foremost, with a view to fostering and extending these assets and their uses whenever possible. Beyond this, while NEOps is ultimately a Canadian Forces (CF) and, in fact, a Government-of-Canada-wide issue, the Army must ensure, as much as possible, that its acquisition and integration of all network-related capabilities be governed, first and foremost, by how well they serve Army needs in those missions in which it is a part.[304] Not only would this help to ensure that existing networking strengths are guarded and extended but also that the possibilities which technology does offer can be explored in a manner that reduces the obstacles and risks that accompany it. It would also work to make the most out of the already scarce economic and human resources that the Army has at its disposal.

Capability Requirements

Particularly challenging from an AoT standpoint is the identification and pursuit of capabilities more directly tailored to Army requirements and needs. While its advocates maintain that NEOps possesses a wide applicability, both its theoretical development and practical application have been US-based and heavily focused on the use of NEOps in high-intensity, primarily symmetric, conflict. Work focusing on its applicability to asymmetric conflict (e.g., terrorism, insurgencies) and to operations other than war (humanitarian operations, disaster relief) has been far less apparent.

Yet it is precisely these contingencies that currently represent the main areas of CF and, in particular, Army activity. And it is these areas that will likely remain key Army concerns in the future. Without clearer notions of how a more technologically networked force would enhance Army effectiveness in these areas, concrete ideas about networking requirements (both technological and human) are unlikely to materialize. Nor, for that matter, will it be easy to gain a fully adequate sense of the specific architectures, capabilities and likely costs that transit to a full network capability will involve.

While it is possible, perhaps even likely, that some of the networking capabilities required for use in high-intensity operations would serve equally well in contingencies such as stabilization and peace support operations (PSO), reconstruction efforts and humanitarian aid, basic differences in circumstances suggest reason to be cautious (see Table 7-1). For instance, while high-intensity operations would tend to emphasize prompt identification and destruction of enemy targets from a distance, it is likely that stabilization and peace support operations would require closer soldier contact with both enemy forces and/or indigenous populations. This suggests that the networking capabilities and skills required in each case may differ. Simply put, possible commonalities in capabilities across the spectrum of operations must be demonstrated rather than assumed.

304 To be sure, this will require considerable liaising with other players and stakeholders. Yet the Canadian Army must not be pushed to keep up with other services simply for the sake of keeping up. Decisions must be carefully tailored to maximization of existing strengths. They must also proceed from a recognition of the fundamental differences between the three environments. Adaptation should not occur for the sake of technology but instead for the sake of increased effectiveness.

Table 7-1[305]

Conflict Phases	Intervention (War-Fighting)	Stabilization (Peace Enforcement)	Transformation (Peace-Building)
Information Requirements (Volume, character, etc.)	Basic data on blue and red forces, location and disposition of personnel (military and civilian, etc.).	Data on blue and red forces, indigenous population (friendly and hostile, civilian and military). Finer grained information on AO.	Awareness of all elements involved in peace-building campaign, status of population and authorities. All relevant information concerning society and government.
Decision Complexity / Character	Medium primarily kinetic issues, target identification and assessment.	High kinetic and non-kinetic issues, more nuanced political, cultural and religious issues, etc.	Medium-high economic, political, cultural, legal issues, etc. Quasi-military.
Decision Speed	High destruction and defeat of enemy forces.	High-medium destruction of enemy, pacification of populace, concentration on winning "hearts and minds" growing.	Medium-low. Establish functioning society. Consolidation of "hearts and minds" campaign.
Key Players (In networking activities)	"Blue" forces. All friendly military forces of various services.	Military forces principally land and supporting elements (soldier-centric).	Remaining military forces, civilian support elements, other government agencies, NGOs, indigenous elements, etc.
Requirements for NEOps	Primarily technical means (sensor and surveillance technologies, satellite intelligence). Basic data on enemy characteristics, disposition, location. Robust, reliable sensor-shooter linkages. Medium level.	More and more HUMIT-oriented requirements. High need for fusion of complex data. Perhaps data flowing from contact with adversaries. Need for analytical skill for complex decision making. Very robust.	High need for fusion of diverse types of data. Need for networking beyond military. High need to share. Analytical skills for complex decision-making. Medium to high level of training.

305 From Stephen Metz and Raymond Millen, "Intervention, Stabilization, and Transformation Operations: The Role of Land Power in the New Strategic Environment", *Parameters*, Vol.35:1 (Spring 2005).

It is apparent that research examining *what* networking capabilities make the most sense for international peace support operations, humanitarian intervention and for the domestic operations that the Army is most likely to perform is essential. Such study might include detailed analysis of past operations featuring land force involvement with an eye to identifying those areas in which possession of a networked capability would have led to appreciable gains in mission performance and/or outcome. Identification of the possible technological options and processes that might have been useful in such circumstances would then follow. To the extent that past practice is considered too narrow in focus, investigation could be extended to include the exploration of hypothetical contingencies and/or historical cases which are relevant but which *did not* involve land force participation. By so doing, relevant, cost-effective networking capabilities could be more easily identified and pursued.

A similar strategy might focus on a selective application of networking technologies according to operational function, with certain functions assuming networking priority based both on relative need and the risk associated with adoption. In cases in which potential returns from networking are high and risks are low, incentives for the application of networking technologies would be especially appealing. The sustainment function might prove appropriate in this regard.

Beyond this lies the need to further cultivate and extend the networking skills already present in the Army. Notwithstanding evidence of NEOps-conducive qualities and skills at the level of the individual soldier, a need for broader and deeper change also exists. While a number of doctrinal developments do indeed appear conducive to a more network-enabled land force, theory is not always confirmed by practice. Despite the intent behind mission command and the potential it holds for creating a more network-aware, network-oriented force, possibilities for micro-management and risk-aversion as well as for dogged adherence to old methods and routines continue to exist. Accordingly, arrangements must be created to ensure that the latent potential in such concepts is not squandered and that widespread change in methods of operation is facilitated. In their absence, truly creative networking will remain less a routine than a function of chance and good fortune.

In part, this will doubtless entail a long and arduous process of cultural and institutional change. Yet other, more immediate initiatives may also work to help ensure that possibilities for change are enhanced. In this regard, one possible step would involve the creation of education, training and recruitment programs explicitly geared toward the ability to effectively perform in a network-enabled environment.

Developing techniques for managing and effectively utilizing the vast amounts of information that a more networked force would make available will also be crucial. In their absence, the dangers of information overload and gridlock will remain ever-present. Accordingly, greater attention must be placed on the economics of information, with research efforts focusing on questions such as how much information is required and when, the amount of data which individuals and organizations are realistically capable of absorbing, and the conditions under which information abundance is likely to create a drag on effective decision-making.

Finally, an investigation of potential counters to network-enabled capabilities must accompany their development and acquisition. Possible steps in this direction could include historical analysis of past strategies and tactics employed by forces faced with technologically superior

adversaries, the creation of a multidisciplinary "red teams" or cells charged with brainstorming counters to networking capabilities, and the inclusion of such analysis in any simulation and gaming involving network-enabled forces. This would not only help guard against the possible vulnerabilities that could attend a networked force but increase the prospects that the force that is fielded offers value for money.

Knowledge

The Operational Environment

Trends indicate that between now and 2021, the CF will acquire numerous sensor capabilities to suit the requirements of various levels of command on both domestic and expeditionary operations. There will be new requirements regarding the type and quality of situational awareness (SA) at all levels of command. Specifically, there will be an evolving sense of SA transparency, with users less involved in the technical aspects of managing SA and yet with more access to essential information due to the networking of information systems. Networking will enable SA transparency to develop laterally at the peer level and vertically throughout levels of command. This transparency will become increasingly apparent with the introduction of better communications systems, new approaches to knowledge management (KM), automated information fusion, autonomous sensor systems and robotics.

Sensor Fusion and Knowledge Management (KM)

The foundation of sensor fusion and KM will be the distillation of information from myriad sources into knowledge, understanding and effective support to decision-makers. Knowledge management consists of the deductive reasoning and processes that provide the impetus for information collection and the SA produced to meet the requirements of decision makers. An integrated, systematic approach to KM will enable the right type of sensor capabilities employed to collect the right type of data that will meet the requirements of decision-makers, whether it involves sensors related to critical sensor-shooter links or those sensor systems that may support larger, integrated effects objectives.

One of the key challenges will be to standardize KM requirements within a JIMP environment—primarily the identification of required information, the planning and coordination of data acquisition strategies, and the timely distribution and sharing of KM products to achieve an overall holistic effect. Above all, successful KM will allow flexibility in operational tempo and enhance the battle rhythm of key decision-makers.

One aspect of KM is support to collaborative planning. The ability to conduct collaborative planning at all levels of command is essential, and it is important to note that most technological capabilities in 2021 should be designed to support planning and decision-making not replace them. Synergism in collaborative planning can be achieved through the employment of high-speed communications; standardized, joint, digital map data; standardized information fusion capabilities; and comprehensive, networked, analytical capabilities to enable rapid analysis, scenario prototyping, war-gaming and mission rehearsal.

Another aspect of KM is sensor mission tasking, coordination and re-tasking. In order to enable decision-makers to share their vision, guidance and critical information requirements,

KM first of all ensures that the right sensors are deployed at the right time to gather the right data. The tracking of taskings, data and subsequent reports produced falls within the purview of collection coordination intelligence requirements management (CCIRM). The planning, tasking and coordination of sensor systems is the responsibility of intelligence surveillance and reconnaissance (ISR). The successful management of CCIRM/ISR will result in a collective, holistic effect being achieved amongst sensor systems, thereby enhancing battle rhythm flexibility and economy of effort. It will be important to effectively exploit myriad sensor systems in a JIMP environment, thereby requiring a robust CCIRM/ISR management capability complete with good communications to all JIMP contributors.

KM wouldn't be complete without the processing of the data collected from sensors and the analysis and fusion of the results into knowledge that is then distributed in a timely manner as SA.

Effective processing and handling of the sensor data that JIMP contributors provide will be one of the greatest challenges in the 2021 environment. Automated sensor fusion may be a key enabler in a JIMP environment, however, common data strategies have to be achieved in order for this to happen. Generally, automated sensor fusion involves the processes whereby data from sensors is automatically incorporated with other sensor data and fused to become knowledge and understanding. Once common data strategies have been achieved amongst JIMP sensor contributors, successful automated sensor fusion will comprise a core capability, enabling the rapid classification, correlation and aggregation of sensor data. The resultant SA will allow the full understanding and subsequent exploitation of all facets of the human, informational and physical planes of the operational environment and their potential effects throughout a given mission as it evolves. Successful automated sensor fusion will be transparent to all users. Its greatest effect will be to enable decision-makers to rapidly develop and share their vision, guidance and critical information requirements. This will only work, however, if the knowledge and understanding are filtered and managed to separate important knowledge from the rest and the relative infrastructure and processes developed in tune to the battle rhythm of the decision-makers. If not, then key decision-makers could be overwhelmed with irrelevant knowledge at critical points in decision-making.

Sensor Systems

In 2021, there will be networked, mobile, autonomous sensor systems capable of being deployed in complex environments and providing multi-dimensional information. Mobile, autonomous sensor systems already exist, and the most important developments will be in the realm of networked systems and artificial intelligence (AI). Networked systems will enable autonomous cross-cueing between sensor systems with regards to target development, thereby decreasing the time lag between sensor and shooter, while increasing SA and improving battle rhythm. A networked sensor system should be capable of doing the following:

- Adapting its surveillance to the environment (complex versus open).
- Conducting automatic self-diagnosis and self-repair.
- Confirming the status of other sensors.

- Automatically surveying its area of operational responsibility (AOR).
- Interrogating anomalies and utilizing networked databases.
- Automatically fusing sensor data, resolving classification, correlating and aggregating of data and publishing its results.
- Updating its own SA and that of other sensors within the system and other systems.
- Automatically coordinating its surveillance coverage with other sensors and with other sensor systems.
- Automatically adjusting its databases regarding changes to digital map data and relaying the changes to other systems.
- Automatically adjusting the surveillance coverage between sensors and re-position sensors if necessary.
- Interfacing with a variety of users and possessing multi-tasking capability.
- Achieving successful identification friend or foe (IFF) between sensor systems.

Beyond 2021, sensor system development will most likely focus on:

- Self-defence.
- Planning and deployment of own sensors.
- Self-awareness, AI and the human dimension.
- Neural human-machine interface.

Other Operational Functions

Command

Knowledge superiority in military operations requires dominant battlespace awareness and visualization.[306] By increasing the timeliness and quality of SA as well as sharing access to all decision-makers, all levels of command will be empowered in a networked environment of increased operational tempo.

Sensor fusion and knowledge management comprise key enablers to support Command, specifically during the operational planning process. Networked KM will ensure that decision-makers receive the SA regarding the opposition force, weather, terrain and friendly troops that they need to define mission parameters and subsequent critical information requirements. Extensive reach-back capabilities will help to produce the SA that will enable decision-makers to create their vision and provide guidance for information collection. As sensor data is received and information collection further refined, KM will support networked

306 S.G. MacIntyre, M. Gauvin and B. Waruszynski, "Knowledge Management in the Military Context," *Canadian Military Journal* Vol. 4, No. 1 (Spring 2003), p. 35.

mission planning, simulation and modeling and subsequent mission rehearsal at all levels of command.

Throughout a mission, KM will provide Command with the flexibility to rapidly adapt to changes in operational tempo and to modify battle rhythm at will. It will allow decision-makers at all levels of command to understand various aspects of the commander's vision and to share their own vision and motivate others. Knowledge management will allow decision-makers to achieve unique informational advantages that can lead to tactical, operational and strategic effects being achieved. Overall, KM will allow operations to be intelligence-led, with branch and sequel planning being based on accurate foreknowledge and the results of previous effects.

Sensor capabilities will provide decision-makers with timely and cogent SA through networked, autonomous sensor systems cross-cueing other sensor systems to achieve multi-dimensional target development. An effective and robust CCIRM/ISR C2 capability will be required in order for this to happen, especially in a JIMP environment.

Act

Sensor fusion and KM will provide tactical units, sub-units and teams with timely, relevant and networked SA for them to effectively achieve their mission tasks. Of importance will be the requirement for decision-makers to quickly receive the results of sensor fusion and data from individual sensor systems to maintain effective sensor-to-shooter links. Knowledge management will enable decision-makers to ensure that they have the right assets at the right location to achieve effects with economy of effort and minimum collateral damage.

Shield

In future, Shield will involve "being comprised of all measures taken to contribute to mission success by preserving freedom of action and operational effectiveness through managing risk and minimizing vulnerabilities to personnel, information, materiel, facilities and activities from all threats."[307]

In terms of KM, one of the greatest vulnerabilities will be outside influences on the SA that is provided to decision-makers. These influences can be manifested in the physical, moral and informational planes prior to and throughout the duration of a mission.

Networks that enable the sharing of SA will have to be protected from cyber warfare, jamming and sabotage. Software and infrastructure used for collaborative planning, simulation, course of action (COA) development and mission rehearsal will also have to be protected.

As well, intellectual property, including vision, guidance and critical information requirements, will have to be protected from hostile information operations. Overall, centres of gravity that will have the potential to affect mission integrity need to be clearly identified and protected from the instruments of a hostile campaign plan.

307 B-GL-300-006/FP-001 *Force Protection*, draft version of Feb 2006.

Regarding sensor systems, the links to and between autonomous sensor systems as well as the links to any military and non-military sensor capabilities in a JIMP environment will have to be protected. In addition, an effective IFF capability will be instrumental in reducing the vulnerability of valuable sensor systems to fratricide while deployed in complex environments.

Sustain

Knowledge management will enable focused sustainment on operations by providing total asset visibility. With networked, digitized tracking, KM will enable logistics planners to more accurately forecast logistics in-theatre requirements; establish and maintain comprehensive C2; and improve levels of maintenance for military equipment, specifically sensor systems. In complex environments, the wear and tear on sensor systems may be higher than normal, requiring an extensive, robust, networked logistics system of systems capable of self-protection and providing the backbone to mission success in a JIMP environment.

Capability Components

The Sense capability definitions provided below are structured statements of AoT capabilities which, when achieved in aggregate, fulfill the Sense operational function contribution to the overall *Land Operations 2021: The Force Employment Concept*. This section describes Sense capability requirements desired for the AoT, encompassing the full spectrum of military operations, derived from analysis of joint concepts (Canadian Joint Task List), Army future force concepts and other documents developed in support of the strategic operating guidance (SOG) and the Army Strategy. This document informs the gap analysis phase of the Army Capability Development (CD) Process.

The Sense capabilities, closely linked to those of Command, focus on the ability of the land force to collect relevant data from all sources and conduct analysis in order to provide commanders and staffs with the information and intelligence they require to plan and conduct operations. Within the AoT, efforts to provide the foundation for superior battlespace understanding will involve a network of highly responsive sensors providing persistent coverage of adversary targets. A producer-interactive network, continuously synchronized with operations, will enable users to subscribe to both real-time and archived fused data.

The Sense capabilities needed to support operations fall into the following areas:

- The ability to **direct** the collection of relevant information.
- The ability to **collect** information within the battlespace.
- The ability to **process** collected data and information into intelligence.
- The ability to **disseminate** relevant information and intelligence.

Direction/CCIRM. The Adaptive Dispersed Operations Operating Concept requires the ability to exercise appropriate, effective and agile command and control of Sense assets at all levels. This capability is linked to the Sense enabling concept of knowledge management by the requirement to conduct sensor mission tasking, coordination and re-tasking. The

tracking of taskings, data and subsequent reports produced falls within the purview of CCIRM. The C2 structure must be modular and tailorable in order to fit with a variety of organizations across the full spectrum of military operations. Examples include the capability to synchronize ISR with operations, task and dynamically re-task assets, monitor/track assets and their activities and plan and assess collection operations.

Capstone capabilities for the direction of Sense assets include: asset control and optimization tools; CCIRM and RFI tools; planning and assessment tools; priority intelligence requirement (PIR) and information requirement (IR) development, refinement, dissemination and integration; ISR synchronization and display tools; and distributed collaboration of manned/unmanned platforms.

Collection of Battlespace Information. The Adaptive Dispersed Operations Operating Concept requires the capability to detect, identify, characterize and track items, activities, conditions and events of interest to commanders and decision-makers. This capability includes surveillance, reconnaissance and information collection from both open and clandestine sources. The following contributing capabilities are critical for observation and collection: ready access by friendly forces, broad area surveillance, focus/stare on targets of interest and measure and monitor environmental conditions.

Capstone capabilities for observing and collecting information within the battlespace include:

- Control sense forces to obtain by visual observation, or other detection methods, information about the activities of an enemy or potential enemy or tactical area of operations. This task uses surveillance to systematically observe the area of operations by visual, aural, electronic, photographic or other means.
- Find, fix, track, target and assess (engagements) IEDs, weapons, munitions and full-spectrum chemical, biological, nuclear, radiological explosive / weapons of mass effect (CBNRE/WME).
- Detect, image and characterize activity within urban structures.
- Detect, identify and track with precision friendly and enemy forces, neutrals and other groups in close proximity at stand-off distances, including individual leadership figures and high value targets, in a complex and chaotic urban environment.
- Detect, image and characterize activity in sub-surface locations.
- Find, fix, classify and track friendly, enemy and neutral fixed and moving equipment and people.
- Display and record in the common operational picture (COP) the successive positions of a moving contact.
- Collect environment information to obtain information that affects a commander's possible courses of action. Considerations include the characteristics of the area of operations.

Information includes physical environment, health standards / endemic disease and social/political/economic factors.

- Observe, collect and characterize socio-cultural and institutional data and indicators—including religious, ethnic, political, economic and physical (infrastructure, natural resources)—to predicatively assess the impact these spheres will/can have on planned or on-going military operations.
- All facilities, fixed and mobile (including those sub-surface and in urban areas).
- Independent events, of either human or natural source (riots, explosions, CBRN plumes, etc.).
- Organizations (intergovernmental organizations [IGOs], cells, conclaves, etc.).
- Assess and monitor the needs, perceptions, actions and reactions of indigenous population groups.

Processing / Sensor Fusion / Knowledge Management. The Adaptive Dispersed Operations Operating Concept requires the capability to process gathered data, information and intelligence. Land operations in the 2021 timeframe will demand SA tools that are superior to those of opponents for anticipating their reactions, for sense-making, for problem solving and for superior decision-making.[308] The foundation of the Sensor fusion and knowledge management (KM) enabling concept will be the processing of information from a myriad of sources into knowledge, understanding and effective support to decision makers. Beyond stove-piped friendly (Blue), adversary (Red) and environmental (Brown) SA, the network will support the creation of an integrated knowledge base. This knowledge base will, in turn, facilitate environmental systems analysis with a view to determining root causes of conflict and subsequently inform campaign plan lines of operations and an effects-based approach to operations. Knowledge management consists of the deductive reasoning and processes that provide the impetus for information collection and the SA produced to meet the requirements of decision-makers. An integrated, systematic approach to KM will enable the right type of sensor capabilities, be they technical or non-technical, military or non-military, to be employed to collect the right type of data that will meet the requirements of decision-makers, whether it involves sensors related to critical sensor-to-shooter links or those sense systems that may support broader effects based approaches.

Capabilities for extraction and processing of battlefield entities from observations include:

- Automated/aided object recognition from imagery derived from electro-optical (EO) / infrared (IR), synthetic aperture radar (SAR), multi-spectral/hyper-spectral (MS/HS) and video sources.
- Tracking of ground objects from moving target indicator (MTI) radar.
- Detection and geolocation of objects by acoustic, seismic and magnetic sensors.

308 S.G. MacIntyre, M. Gauvin, B. Waruszynski, “Knowledge Management in the Military Context,” *Canadian Military Journal* Vol. 4, No. 1 (Spring 2003), p. 35.

- Identification and geolocation of radio frequency (RF) emissions.
- Biometric measurements of individuals.
- Soldier/observer field reporting.
- Free text processing of reports and of open-source media.
- Human speech translation and exploitation.
- Correlation of battlefield entities to remove duplications.
- Combining tracks of entities to provide enhanced coverage.
- Capacity to analyze relationships between entities, infer aggregated higher-echelon objects.
- Capacity to analyze activities by entities, aggregate into larger concepts of activity.
- Ability to hypothesize and assess potential current courses of action, and future impacts to friendly operations.
- Provision of analyst archiving, collaboration, mining, visualizing and assessment tools.
- Integration of terrain, weather and cultural/doctrinal factors into analysis.
- Development of decision-making tools to identify socio-cultural issues and needs in order to predict the perceptions and actions and reactions of indigenous population groups in relation to ongoing or planned military operations.
- Fusion of information routinely collected by both military and non-military organizations that routinely interface with the indigenous population.

Notes on Processing

The capability to process gathered data, information and intelligence is the critical supporting component of the Land Operations 2021 Enabling Concept of Fusion and Knowledge Management. Processing of information is the ability to use open and protected methods to discern patterns, opportunities and vulnerabilities and characterize information concerning an adversary in order to facilitate superior decision-making. This capability is a combination of both the ability to conduct detailed, in-depth analysis of very specific phenomenology and the ability to fuse information from a wide variety of sources in order to create valuable insights and actionable, relevant information.

Knowledge management includes horizontal and vertical integration of information from sensors, analytic centres and decision-makers. The following contributing capabilities are critical for knowledge management: smart pull/push information, shared plan visibility and maintaining an open archive. Given that the nature of information is both synergistic and contextual, it is critical that analysts and agents be able to access past information to derive maximum benefit from the current findings. Effective knowledge management is critical to understanding the battlespace environment to enhance full-spectrum engagement.

Fusion

Fusion is the critical technology that underpins these components and in many circles has become synonymous with battlespace understanding functions. Fusion, by definition, is a series of processes to transform observable data into more detailed and refined information, knowledge and understanding. These processes, by their very nature, involve a mixture of automation and human cognition. All of the capstone capabilities required and outlined above have one or more aspects of fusion embedded within their constructs.

Just as the Battlespace Understanding Functional Concept "begins and ends with the decision maker," so does the Army's development of battlespace understanding capabilities that provide actionable intelligence for commanders and decision-makers at all echelons. Actionable intelligence provides commanders and soldiers a high level of situational awareness delivered with the speed, accuracy and timeliness necessary to operate at their highest potential and to conduct successful operations. To achieve actionable intelligence, the future force must bring to bear a constellation of highly responsive sensors (e.g., unattended, human, intrusive and remote) providing persistent, redundant and tailored coverage of the battlespace.

Sources of collected data will interact over a network to provide all force elements with the highest quality fused data. Within this producer-interactive network, force elements will subscribe to products or data (including archival data). Software agents will broker data and products, posting some unprocessed information. In this manner, all are provided access to common data, enabling joint, allied, and coalition warfighters to construct tailorable, relevant pictures.

Commanders will maintain a deeper understanding of potential enemy courses of action by integrating archived and real-time data to auto-populate models and simulations and by leveraging these models and simulations in training and operations to perform rapid and continuous alternative forecasting. By providing simultaneous current and forecasted future depictions of intelligence resources, and insight into their potential responsiveness, the ISTAR officer will be able to quickly re-task multiple sensors to react to emerging operational situations.

Battlespace sensing (from manned aerial and ground platforms, unmanned aerial and ground vehicles or forces) will be incorporated into operations planning and execution. Environmental information (e.g., weather, terrain and civil component) will be augmented with information from battlespace sensors. All sources of information will be integrated into modeling and simulation to facilitate an understanding of the potential impacts of various courses of action.

The Fusion Process

The commander establishes information requirements based on mission, enemy, terrain and weather, troops and support, time and civil considerations. The fusion process, operating over integrated communications networks, includes accepting data from all ISTAR sources, organic and external. Sensors include combat platforms and soldiers, organic manned and unmanned reconnaissance and surveillance platforms and external constellations. Fusion ensures that a correlated, non-duplicative set of information is available across the force and

provides context to the information that has been acquired, thus enabling situational understanding. This requires that data and information be converted as quickly as possible into actionable intelligence.

There are six levels of fusion (0-5). However, it is levels 1 through 3 that add progressively greater meaning and involve more analysis. Level 4 is continuous and occurs at all levels of fusion. The fusion levels are:

- Level 0: Organize (extracts battlefield entities).
- Level 1: Correlate/Identify/Resolve (correlates battlefield entities).
- Level 2: Aggregates/Determines/Interprets/Determines/Hypothesizes/Resolves (associates and aggregates entities, determines activity and current courses of action).
- Level 3: Interprets/Determines/Predicts (assesses future red/blue courses of action).
- Level 4: Assesses/Reviews Performance (serves as feedback of Levels 1-3).
- Level 5: Visualize (provides user interface to collected and fused data).

Modeling, simulation and forecasting is the ability to utilize collected information to create an environment that allows for modeling, simulating and forecasting in order to increase understanding, increase confidence, improve the planning (and execution) of courses of action and decrease risk for commanders and analysts. Modeling, simulation and forecasting activities range from accurate and timely weather predictions through support of operational rehearsals, training exercises and military education. The following contributing capabilities are critical for modeling, simulation and forecasting: auto-populate models and simulations; identify enemy courses of action; and integrate cultural, social and other non-military issues into predictive forecasts. The sub-capabilities of modeling, simulation and forecasting include: 3D/Holographic visualization tools; human intelligence (HUMINT) and all-source collection models; social/cultural models of communications and influence; adversary courses of action models; tech collection models to predict/tailor future collection, based on environmental and sensor constraints and adversarial patterns of operations; and models to assess and prioritize reconstruction efforts in relation to the impact they will have on the adversary's decision cycle and indigenous population perceptions.

Dissemination. The Adaptive Dispersed Operations Operating Concept requires the capability to disseminate relevant information and intelligence in an appropriate form and by the most effective means to those who need it. This capability is linked to the Sense enabling concept of knowledge management through the extant requirement to provide information and intelligence to help decision-makers understand the current and assessed future situation within the battlespace.

Chapter 8

Omni-Dimensional Shield in Future Conflicts

By Lieutenant-Colonel Steve Fritz-Millet

> *"Force Protection remains of paramount importance, second only to mission success."* —R.J. Hillier, General, Chief of the Defence Staff, 25 April 2006.

Omni-Dimensional Shield. Omni-Dimensional Shield is an enabling concept which supports the adaptive dispersed operations (ADO) operating concept. It is a holistic concept that addresses the requirement to protect our forces in the conduct of their missions from an increasingly wider and more lethal variety of threats inherent to the future security environment (FSE). While Omni-Dimensional Shield is an enabling concept in its own right, there are elements of Omni-Dimensional Shield embedded throughout the other operational concepts. For example, the network enabling concept has an inherent requirement to protect that network from electronic, physical and cyber attack. The provision of such protection is encapsulated in the Shield operational function. Hence, there is often overlap between the operational functions and ADO and its subordinate concepts.

Shield from What? The operational function Shield and the operating concept Omni-Dimensional Shield are to a large extent threat-driven. More to the point, when one says "force protection" the first question that come to mind is, protection from what? Omni-Dimensional Shield includes protection from five general, distinct types of threats: chemical-biological-nuclear-radiological-environmental (CBRNEnv) threats, aerial threats, psychological threats, direct kinetic threats and attacks from friendly forces (fratricide). Note that shielding from electronic or cyber attack is inherent to the network operating concept and is therefore grouped under the Command operational function. While current Army doctrine and other CF publications provide adequate force protection guidance for the Army of Today, the FSE envisages changes to the nature of some of these threats. Therefore, some consideration must be given to how force protection must be adjusted in order to contribute to mission success for the Army of Tomorrow conducting ADO. This manifests itself in the concept of Omni-Dimensional Shield.

CNRNEnv Threats. In the FSE, we can anticipate that our adversaries will have benefited from weapons of mass destruction (WMD) / arms proliferation, advances in technology and increased access to technical information and equipment required to weaponize CBRN agents. As well, the environment will continue pose new threats to friendly forces. The recent epidemics of Severe Acute Respiratory Syndrome (SARS) and bird flu (and their cousins and mutations) are examples of the environmental threats that our forces could face on operations in the future.

Aerial Threats. While the threat from conventional fighters, bombers, attack helicopters and tactical ballistic missiles has diminished considerably with the end of the Cold War, the possibility of such threats arising in the long term cannot be discounted. In the near to mid-term, the more likely aerial threats will come from the improvised use of civil aircraft in

military roles (a crop duster to disperse chemical agents, for example), cruise missiles, unmanned aerial vehicles and artillery, rockets and mortars. Countering these new types of threats will require increasingly better detection, acquisition and engagement systems. Noting that it can take up to ten to fifteen years to fully introduce a new capability, this has potentially significant capability development and force structure implications.

Psychological Threats. Potential adversaries that are no match for us in a conventional battle will look for ways to attack our will to fight using psychological means. This could include attacks on our homeland, attacks directed to provoke our forces to action that would ultimately undermine our chances of success and attacks to undermine our legitimacy and effectiveness both in and out of theatre. These types of threats are often difficult to counter, particularly when they are often settled in the arena of public opinion and the media.

Direct Kinetic Threats. Weapons proliferation, improved access to more sophisticated weapons and advances in technology will require force protection from a more lethal and diverse threat portfolio. Disturbingly, these advanced weapons systems are becoming more precise and effective, while automation allows for the reduction of training time required to achieve proficiency. Thermo-baric weapons provide an example of a relatively low cost, highly lethal weapon that friendly forces may face in the FSE. Recent improvements in the use of improvised explosive devices in Iraq and Afghanistan provide clear evidence of the ability of an adversary to adapt and learn with the purpose of exploiting the critical vulnerabilities of a conventional military force. This in turn has precipitated substantial capability development effort to counter those threats. This trend is likely to continue in the FSE and has significant force protection implications for both individual and vehicle protection.

Attacks by Friendly Forces. The public, political and military threshold for tolerance of fratricide incidents appears to be diminishing, a trend that is likely to continue in to the future. The conduct of operations in a joint, interagency, multinational and public (JIMP) environment poses additional challenges in terms of identification of friends, foes and neutrals and increases the likelihood of an "event." While advances in technology offer the possibility of more integrated and networked forces, a tendency for nations to develop their own autonomous systems and not share information will to some extent undermine the full potential that technology offers. Further complicating the matter is the past practise of the services (Army, Navy and Air Force) to emphasize communications between the same services of different nations rather than communications between different services of the same nation. As FSE sees an increased likelihood of a "Team Canada" joint approach to missions, some effort will be required to ensure that the Army, Navy and Air Force have an integrated approach to avoidance of fratricide.

Shield What? Omni-Dimensional Shield is complimentary to the operational function Shield, which is a layered, integrated and fully dimensional function that seeks to prevent any influence of friendly forces across the *physical*, *moral* and *informational* planes that could affect survivability or freedom of action. In essence, Omni-Dimensional Shield is a concept that includes the requirement to identify and protect the friendly force centre of gravity and its subsidiary critical vulnerabilities from attack by an adversary. In the future, Shield in the physical plane will focus on the traditional defensive concepts to include the protection of soldiers, partners and non-combatants, platforms, systems, equipment and faculties. In the informational plane, Shield will likely focus on the protection of friendly information, information

products, information systems and friendly force activities. It must be acknowledged that a network-enabled force accrues both the benefit of an increased ability to share information and the increased risk of an adversary accessing or disrupting that same network. In the moral plane, adversaries will seek to undermine the legitimacy of our mission and our force. Simply put, they will attack our will to fight. To counter this, increased emphasis training in the areas of ethics, mission legitimacy, resistance to psychological threats, etc. will be required.

Shielding Measures. The operational function Shield and Omni-Dimensional Shield are also complimentary to the CF doctrinal concept of force protection, which is comprised of "all actions and measures taken to contribute to mission success by preserving freedom of action and operational effectiveness through managing risk and minimizing vulnerabilities to personnel, information, materiel, facilities, institution and activities from all threats." The stages of protection—"Precautionary" (predict, prepare), "Indicate and Warn (detect, warn), "Mitigate" (prevent, avoid) and "Manage Consequences" (recover, learn)—are unlikely to change in the AoT timeframe. The specific actions taken within each of the steps will change as doctrine, equipment, technology, etc. evolve.

Future Shielding Trends

Vehicle Design. Since the develop of armoured fighting vehicles during World War I, there has been a constant tension between the competing needs of protection, firepower and mobility. In recent years, some have added communications to that mix. Any increase in one area comes at the expense of one or more of the other needs. In the face of even more capable asymmetric threats in the future and a gradually reducing tolerance on the home front for casualties, it is likely that the recent trend towards emphasizing force protection in the area of vehicle design will continue. Hence, some reductions in the areas of communication, firepower and/or mobility will be required. Furthermore, on the non-contiguous battlefield of the FSE, many vehicles that were not afforded a high degree of protection in the past (logistics vehicles as a case in point), will require a level of protection commensurate with their armoured fighting vehicle counterparts. Some economies in weight will undoubtedly be achieved through advances in the design and composition of protective materials. However, this will drive the per-unit cost of the vehicles up considerably.

Blending of Future Capabilities. Advances in technology may see the blending of some capabilities. For example, if an effective, tactical directed-energy weapon can be developed, it might provide the counter-rocket artillery and mortar (CRAM), air defence and direct-fire weapon capabilities in a single system. In this case, there is a blending of the Shield and Act operational functions in one platform. This will result in some changes to the traditional force structure and military occupation models that have been employed since World War II. Research and development and technology watches should provide ample warning of when such blending may occur so that the appropriate force structure and military occupation changes can be made in advance.

Force Protection Planning. Due to the fact that agile adversaries will be thinking up clever new ways to conduct attacks and that no force can ever be completely protected from everything, there will always be a risk of casualties during an operation. For these reasons, continued improvements must be made to criticality, threat, vulnerability and risk assessment

processes and tools. The processes and tools should become increasingly automated, better integrated with the operational planning process and, ultimately, serve to enable the commander to better conduct ADO in the FSE.

Chapter 9

An Operating Concept of Sustainment for the Army of Tomorrow

By Lieutenant-Colonel Ron Bell

Introduction

Land force administration in the battlespace traditionally deals with the whole matter of logistics: the supply distribution chain, the land equipment management system and health services support. Administration of the force also includes the personnel management and services and financial administration that must be provided to the force, including amenities, mortuary, chaplain and legal services. The Army refers to this set of activities in an area of operations as combat service support. Until fairly recently it was provided through a robust and dedicated echelon system down to the sub-unit level, containing all of the materiel, services and organizations required for the land component to conduct all types of operations in a relatively sustained manner. This was an appropriate system for the conduct of conventional warfare in the past, but some redundancies within this system were seen to place unacceptable demands on ever-more-scarce human, financial and equipment resources.

The use of the echelon system according to established doctrine has not been the practice during a number of recent Canadian Forces operations. This is in large measure due to force reductions in past years and because we have been able to get away with it in many of the security environments in which we have operated. Due to challenges in managing personnel levels in a number of support occupations and other restrictions on the deployment of sufficient support personnel, vehicles and equipment into theatres of operations, all lines, levels and roles of combat service support are presently provided to in-theatre forces through a single entity known as the national support element. The combat and combat support forces have often been stripped of much of their integral support and depend on the national support element to provide the entire range of support services. The logic of this approach has been seriously challenged within a contemporary operating environment that has featured significantly increased combat operations over the past year. This experience has generally disabused the institution of some previously held assumptions regarding the attempts to do combat service support “on the cheap” and has reinforced the wisdom of some of the enduring tenants of established doctrine.

This functional operating concept for Canada’s Army of Tomorrow, while including the introduction of new capabilities, is premised on the use of a robust and well defined echelon system for the provision of sustainment to the land force in adaptive dispersed operations. This echelon system will necessarily be leaner but more integrated, adaptive and flexible than the large structures of the past. It will emphasize velocity rather than mass and will continue to depend for its effectiveness on well trained, well equipped and well informed soldiers and leaders.

A concept of sustainment for the Army of Tomorrow must, in fact, also consider broader factors such as force generation and sustainability, including organizational structures, training and human factors. For the capability development endeavour to be most successful, there must be the institutional will to reinforce useful capabilities that presently exist, to build new capabilities that will continue to be needed out into the future and to ensure sustainability over time. This concept of sustainment for the Army of Tomorrow will deal, in some respect, with all of these relevant aspects.

Purpose

This concept of sustainment for the Army of Tomorrow is put forth as guidance for the Land Force Capability Development Process. It comes about due to the need to deal militarily in an effective manner with the future security environment. It groups together a set of traditionally functional and enabling concepts and capabilities (replenishment, repair and recovery, health services support, personnel support services, etc.) and is directly subordinate to the operating concept *Land Operations 2021—Adaptive Dispersed Operations: A Force Employment Concept for Canada's Army of Tomorrow*. The concept described in this document pertains to the land force operational function of Sustain, and the *Land Operations 2021* functional concept of sustainment and must be integrated with future operating, functional or enabling concepts dealing with the other operational functions of Command, Sense, Act and Shield and any other relevant future functions. It spans the strategic to tactical levels, though focusing on the land operational and tactical employment of deployed forces, and should be viewed within a joint, interagency, multinational and public (JIMP) context. It contains sufficient detail to inform the structures, doctrine, equipment and research projects in support of the design of the various capabilities described as enablers for the concept.

Main Characteristics of the Concept

General. The military requirement to provide assured support to widely dispersed land forces will demand a highly integrated, adaptive and flexible sustainment system. As a force becomes more dispersed, it is assumed that the sustainment system will need to transition from a primarily ground-based system to one that contains more air-based support, although it is highly likely that there will be both ground- and air-based sustainment activity within any given operation. Reliance on only land-based sustainment in a non-permissive security environment will continue to threaten tactical operations considerably, especially when dispersion goes below company or squadron level.

Focused Logistics. A focused logistics capability will contribute to the relevance, agility and decisiveness of the force through the sufficient provision of combat service support with the highest level of certainty. It will put the right support in the right place, at the right time. It will depend on the global projection of capabilities tailored to all envisioned tasks, and shall include total information management and precision service delivery capabilities that are technologically advanced, well protected, economical and sustainable.

Networked sustainment planning tools and specialized delivery methods are the basis for a focused logistics capability. Assurance of support is the essential characteristic of focused logistics. This will be achieved largely through a system that is integrated, adaptive and flexible. Integration refers to the ability of all aspects of the sustainment system to work as

part of a unified and well coordinated system of service delivery. This demands a technology-enabled sustainment information management system as well as a service oriented mindset among the sustainment system's staff and personnel. Adaptivity has, primarily, to do with the scalability of the echelons to the precise capability directly required by the supported force. It has not just to do with task-tailoring the scale of the organization and its holdings but also with the physical and mental capacity to adopt the battle rhythms and work in the operating conditions of the mission. The notion of flexibility is based upon the ability to provide options for the means and methods of support to the force through the effective use of a variety of platforms, total asset visibility and command and control.

Asset Visibility and Tracking. Critical to an integrated, adaptive and flexible sustainment system is a fully networked asset tracking and in-transit visibility capability. Only through the ability to track the location of all sustainment activity can the system truly support widely dispersed forces in an effective, efficient and economical manner. For instance, it will contribute to a reduced logistics burden in terms of daily operational supply and other forward stock holdings, as there shall be real-time total asset visibility that will allow better risk management of commodity levels. This capability is critical to the efficient and effective use of resources supporting dispersed forces. Complete digitization of the force not only supports asset-tracking requirements but may also reduce maintenance and repair demands through actual status reporting by built-in sensors in equipment or more rapid initiation of the medical evacuation and treatment system through the use of biomedical information telemetry. Optimization of the provision of administration to the force shall come through the widespread use of a network system of sustainment information management, command and control and collaborative planning tools.

Materiel Handling Systems. There shall be a large increase in the use of pre-configured loads and containerization as methods of moving supplies. Combat-configured loads will reduce handling and bulk breaking requirements throughout the distribution network. Load assembly will take place at the time and location best suited for this activity. The sustainment system, including the land-based transport fleet, must be fully capable of handling containers and other configured loads at all levels, from the strategic- through to the tactical-level consumer.

Dedicated Air Assets. Aircraft must be dedicated to both replenishment and medical evacuation, especially in non-permissive security environments. Timely evacuation, in particular, will depend on the ready availability of aircraft. A practice of double-tasking aircraft will result in the failure of the sustainment system to support adaptive dispersed operations unless priority is given to critical sustainment activity such as medical evacuation and emergency replenishment.

Protection. Combat skills training and adequate equipment will also be a high priority for combat service support elements, as the enemy forces will continue to focus attacks on what they perceive as important, yet "soft," targets. Combat service support vehicles must be hardened—armoured and armed appropriately—and forces must be prepared to adopt the proper defensive posture for the future security environment in which they will operate. A widely dispersed force will demand that combat service support elements be self-protecting to a much higher degree than they are presently and given additional protection forces when required.

Science and Technology. Advances in technology such as robotic platforms and precision aerial delivery systems shall be leveraged to reduce the strain on the sustainment system for dispersed operations. Autonomous platforms could be used to carry supplies for small teams or deliver larger loads to forward operating bases, while precision aerial delivery shall support forces on the ground in difficult-to-access locations.

Economy. Advances in portable power generation and water purification, as well as reductions in ammunition and fuel expenditures, and maintenance requirements brought about by advanced technology, have the potential to significantly reduce the demands on the sustainment system.

Strategic Force Projection. To support future operations, rapid force projection capabilities such as fast shipping and strategic airlift will be required. The Army of Tomorrow must also be capable of intra-theatre manoeuvre resulting in rapid concentration of force in order to achieve the necessary shaping, decisive and sustaining effects. It will be necessary to project and protect sustainment activity and resources throughout the expanded, complex, non-contiguous battlespace. Therefore, more capable and responsive force projection capabilities will be needed.

Force Generation. The Army of Tomorrow must have the ability to generate task-tailored forces that are interoperable in a joint coalition or alliance context and capable of conducting operations throughout the spectrum of conflict within the future security environment. This approach requires a force structure that can generate units with capabilities tailored for the specific tactical operations they are expected to conduct, including offensive, defensive and stability operations. Thus, an adaptable force structure that permits grouping of personnel and capabilities from across a wide range of military functions is required. It must enable social cohesion, discipline, mastery of complex and physically difficult tasks and the infusion of the warrior ethos.

Training. Knowledgeable, resilient and adaptable people are fundamental to achieving the most important capability of the land force—*soldiers*. The proper distribution of this valuable capability will have to be developed and maintained over considerable time by training and educating joint coalition commanders, staffs and personnel for demanding and complex operations. Sound preparation is essential to producing each operationally ready soldier.

Discussion

The Sustainment Operating Concept

Context. In the past, the organization of the sustainment system reflected the linear structure of the battlefield. The system relied upon mass, depth and volume to reduce risk and the effects of uncertainty. The system was inefficient in terms of the use of human and other resources, its footprint was large, it was not particularly agile, and it operated primarily in a reactive mode. However, high tempo, dispersed, non-linear, non-contiguous and simultaneous actions will most likely continue to be characteristic of operations in the future security environment—in fact, they are likely to accelerate—and this will dictate changes in the way sustainment services are provided. And despite the ultimate desire to reduce the overall sustainment footprint, the limiting factor on the tempo of operations in general will continue

to be the ability to support the force logistically. Thus, assurance of support to the force, and the concomitant risk to the operation overall, shall not be compromised by reduction of support structures before the capability is offset by technology, efficiency or some other emerging enabler. (A sound concept for sustainment continues to incorporate the enduring fundamentals of foresight, economy, flexibility, simplicity, cooperation and self-sufficiency.)

Adaptive dispersed operations will demand a combat service support system that is proactive. It will be necessary to anticipate sustainment requirements through increased situational awareness and knowledge and to find ways to balance the need to optimize and reduce the sustainment footprint while at the same time ensuring responsive and adequate support. As an example, the concept of reacting to daily demands and planning to push combat supplies forward on rigid timelines without a clearly articulated requirement can no longer be followed—it is wasteful. The ability to deliver tailored replenishment loads where and when they are needed is essential to reducing overall holdings and the sustainment footprint. In order to achieve this reduction, the Army must actively pursue such enablers as containerization, total asset visibility and a mix of distribution capabilities to include sea, land, air, aviation, precision aerial delivery and autonomous systems that will remain effective in the future battlespace. All elements of the sustainment system must be led and managed as a unified and integrated set of capabilities, achieving a high level of coordination among the various functions and with the supported force.

Sustainment Information Management. There are a number of keys to achieving this vision of sustainment. Perhaps the most important is the dramatic increase in situational awareness through the accurate and speedy availability and processing of sustainment data and information, including sustainment requirements from the supported force. A sustainment information management system that is linked to the tactical command and control network, and which will also link the tactical to the strategic levels, allowing the real-time use of institutional Canadian Forces materiel, maintenance, medical and personnel management assets, must be available to the operational and tactical force down to the lowest sustainment levels. This shall facilitate real-time analysis of sustainment situations and will even result in accurate forecasting of the demand at the individual vehicle and soldier level. Situational awareness of the entire relevant sustainment system is fundamental to ensuring the system is able to focus its priorities as required throughout a theatre of operations in an integrated fashion.

A well-developed sustainment information management system will enable the viewing and use of critical, unimpeded and real-time information, permitting the planning and delivery of anticipated, rapid and precise support. Achieving ever increasing levels of total asset visibility is an essential element of this capability. Total asset visibility implies an awareness of the location, quantity and condition of assets, from manufacture through transit, usage and disposal. This capability is necessary in order to be able to forecast the ability of the entire system to react to unexpected demands. To be truly effective, a total asset visibility system must include the ability to re-route assets to meet sudden demands. A full awareness of the tactical situation and sustainment requirements, coupled with asset visibility, asset tracking and adequate distribution and command and control means, will facilitate a sustainment system that will emphasize velocity over mass, allow the most appropriate level of

mission-based[309] monitoring and control of the entire process and that will provide assured and direct delivery from a number of nodes in a form immediately beneficial to the soldier.

In concert with increasing situational awareness, advanced modelling and simulation capabilities must be included as tools to enable collaborative planning for sustainment operations to be initiated on a predictive basis. A predictive and anticipatory system will allow, for example, the movement of commodities in a controlled and deliberate manner, and permit the system to quickly circumvent problems. The activity can be adjusted to meet changing priorities and situations and will be accomplished quickly and accurately, using the best of all the available options.

The Echelon System. Notwithstanding a distribution-based and networked system, supplies, services and coordination authorities shall be organized along an echeloned structure. The change from present doctrine is that echelons shall not constitute fixed organizations; rather, they will be task-tailored, and what is held at each echelon will depend on the situation. For example, small, temporary stocks of combat supplies along the sustainment pipeline may be able to provide the flexibility to meet changing operational conditions and avoid the inherent risks and inefficiencies of stockpiling at all lines of support. On the other hand, achieving an optimal footprint may dictate that, at times, the quantities or capabilities held at a given level are in fact increased above what might be regarded as the norm. The system must be adaptive in what is held where and flexible in how it is moved forward.

In order to match the task-tailoring, modular approach to organizing combat capabilities, combat service support shall be similarly organized. The depth and breadth of sustainment capabilities at any level will be subject to quick and easy adjustment through the addition or subtraction of capability building blocks. Task organizing or mission tailoring of forces and logistics will be increasingly easy to perform and shall be encouraged. Concurrently, doctrine shall evolve to take full advantage of ever-increasing situational awareness and the advantages inherent in a distribution-based, proactive system. Precision in both planning and delivery, combined with flexibility in the means of service delivery and adequate redundancy, will allow a move away from such things as a rigid replenishment system based on set time cycles and generic demands from the user.

Distribution. The Army of Tomorrow shall see an increase in the use of pre-configured loads and containerization as methods of moving supplies quickly and in accordance with the known need. Combat-configured loads are a potential means to reduce handling and bulk breaking throughout the distribution network. The use of containers shall enhance strategic to tactical deployability of resources and will be used for a multitude of purposes from moving general cargo to self-contained workshops. The sustainment system, including its ground tactical mainstay, the wheeled transport fleet, must be oriented to the use and handling of containers from the strategic interface through to the consumer. A fully functioning sustainment information management system, and total asset visibility and tracking through the ubiquitous use of such things as radio frequency identification (RFID) and positional awareness

309 Just as mission command provides the commander's intent to subordinate commanders with respect to the tactical situation, permitting them to exercise certain levels of discretion in solving tactical problems, logistics leaders must use a similar approach in dealing with logistics problems.

technology, will facilitate timely replenishment on a “pulsed” basis to take advantage of replenishment opportunities and to best meet operational requirements.

The conduct of combat operations and manoeuvre in the future security environment will cause high rates of wear on personal clothing and equipment, weapon systems, electronic equipment and vehicles. Large quantities of replacement parts, particularly tires, shall need to be readily available through a more adaptive organization and flexible replenishment system based on robust and forward-deployed echelons. Wide dispersion of forces will also increase the requirement for these kinds of holdings at echelons below the unit level.

The introduction of precision aerial delivery means for emergency or routine replenishment of forward operating bases or other dispersed forces will bring a significant improvement to the flexibility of the distribution system. This capability, combined with an effective sustainment management system, can, for example, rapidly deploy general support resources held at third line directly to a sub-sub-unit while it manoeuvres in the battlespace and in otherwise inaccessible terrain. This emerging technology has considerable potential for great increases to payload weights, reliability and landing point accuracy in the very near future. All-weather, night-time and vertical and horizontal standoff capabilities are providing significant improvements to the stealth and protection of these assets.

Land Equipment Management System. The materiel maintenance effort of the force will likely continue to place the greatest single demand upon combat service support personnel resources well out into the future. Supported vehicles and equipment must be more reliable and durable, and more easily maintained, which includes faster and more accurate diagnosis and greater use of quick-change assemblies. Technology shall be harnessed to improve the repair and maintenance of equipment, and the effectiveness and efficiency of the maintenance effort wherever possible, to ensure better equipment and vehicle availability.

The challenge of full-spectrum operations will place a greater emphasis on force protection through the more rapid completion of forward repair, greater reliance on recovery, improved tactical situational awareness and degrees of personal protection and a credible defensive posture for repair and recovery assets. Notwithstanding that a great deal of the maintenance beyond that which the operator can do will be conducted in secure forward or main operating bases, the basic tenets of the Land Equipment Management System, including forward repair, shall remain valid. There will continue to be a requirement for level-one repairs to vehicles, trailers, weapons, electronics and miscellaneous equipment to take place in areas that are not secure. Mobile repair teams in support of tactical operations shall be afforded personal and vehicle protection, situational awareness and mobility equal to the supported force.

Increased vehicle recovery capability will be essential, as the higher tempo of adaptive dispersed operations and enemy action takes its inevitable toll on the fleet. There shall be better means of self-recovery for every vehicle, an increase to specialized and general recovery equipment and devices and a capability to quickly backload all family of future combat vehicles within the battlespace. Clearance and denial operations shall continue to be important in order to subvert enemy opportunities to use captured or photographed equipment for propaganda purposes.

Health Services Support. The envisioned increase in operational tempo has a significant potential to produce larger spikes in casualty rates within short spans of time. There will be increased dispersion between supported and supporting elements, and operations in complex terrain and the requirement for the force to deal in an adaptive manner with asymmetric threats throughout the area of operations will complicate the provision of health services support. These factors will contribute to a need for increased resources in order to maintain acceptable evacuation times and treatment protocols. To counter the increased risk, health services support to the Army of Tomorrow shall continue to evolve into a knowledge-based system focused on prevention where possible, early treatment and evacuation where prevention has failed and enhanced forward care when evacuation is, or is likely to be, compromised. Prevention of causalities shall be achieved through protective agents, advanced medical surveillance capabilities that allow early detection of health threats and advanced diagnostic capabilities that identify and confirm the causative agent. Communication of the health threat to force commanders, in terms of real and relative risk compared to other operational threats, will be critical.

Since the vast majority of casualties reaching role-three facilities survive, the greatest gains are likely to be made within the initial hour of wounding. Improvements in first aid—self or buddy—as well as early evacuation over longer distances by air ambulance will pay large dividends in reducing morbidity and mortality. Where early evacuation is predicted to be a problem, fully integrated health services support plans will ensure that scalable, task-tailored and flexible medical support elements, including initial damage control surgery, are well positioned to provide the necessary care.

Protection. The future security environment will continue to present significant challenges to security and force protection. Echelons and logistics convoys will need to protect and defend themselves from, and be able to conduct limited combat activities against, determined adversaries. Armed and armoured logistic variants of the family of future combat vehicles are demanded for high-risk areas and tasks. All combat service support soldiers must be adequately trained and prepared for land combat operations, irrespective of their distinctive environmental uniform. Operations in complex terrain, where movement can be extremely restricted and distances deceiving, present a typical set of problems. Urban congestion, blocked roads, snipers, improvised explosive devices and other human and natural limitations impinge upon sustainment routes and activities, thus restricting options, and can turn an otherwise short trip of a few blocks into a significant combat operation.

Summary

The Army's sustainment system formerly relied primarily upon mass and linearity to reduce the effects of uncertainty, inaccuracy and slow planning cycles. Presently, most of the three lines, levels and roles of support are provided in operational theatres by a single task force support group or joint task force support group constituting the national support element. Such a centralized system cannot adequately serve the needs of the Army of Tomorrow during high tempo, adaptive dispersed operations in the future security environment. In particular, the manoeuvre units and sub-units require dedicated integral support elements. Predictive, knowledge-based sustainment systems that leverage information and technology, and which enable a joint, service-oriented combat service support element, are both essential and achievable. The Army must acquire total asset visibility throughout the entire distribution

system and have the ability to move those assets where and when threats and priorities dictate. Modernization programmes must include the aggressive pursuit of enabling technologies to facilitate distribution, reduce demand, enhance reliability, reduce maintenance and improve casualty care, evacuation and continuing health of our soldiers. Combat service support shall be projected outside the confines of secure bases through the use of dedicated and task-tailored echelons with mobility, protection and situational awareness equitable to that of the supported forces and commensurate with the duties they are expected to perform.

Supporting Concepts

Economy and Emerging Technology. Achieving an optimum sustainment footprint will involve sufficient situational awareness to know sustainment requirements with confidence as well as the reduction of requirements as much as possible through efficiencies brought about by emerging concepts and technologies. The land force shall take advantage of these advances to achieve reductions in fuel, ammunition, water, power, maintenance and medical requirements. As new fleets are procured, emphasis shall be placed on increased reliability and on reducing fossil fuel consumption through weight reduction, improved propulsion systems and alternative energy sources. In vehicles, equipment and weapons, the use of diagnostic and prognostic systems for on-board monitoring, problem diagnosis and fault isolation shall be required so that operator repair through component replacement will become more commonplace. On-board water production and advanced power generation systems should be included in all family of future combat vehicles. Commonality of chassis and propulsion systems shall be pursued along with the use of corrosion resistant materials. The use of lightweight, composite armour will reduce weight and fuel consumption as well as the strain on vehicle components, thus reducing the maintenance burden.

Force Generation and Sustainability. The maturing discipline of the Army Managed Readiness Plan, combined with the force level increases going toward filling out the "hollow" Army (particularly in the stressed occupations), should set the Army on the right track toward operational sustainability. This effort must be reinforced with a recruiting, personnel, training and human resource support system with sufficient depth to deliver the volume of trained and supported personnel required to maintain the institutional force generation and operational employment structures. The goal shall be to have the force generating structures, such as units and formations, optimized as much as possible for direct employment on domestic and expeditionary operations.

The Canadian Forces will need to have the strategic airlift and sealift capacity to move the joint force and its equipment and supplies securely, in the time and volume required. Operationally, there will be an increased requirement to have a cadre of permanently stationed overseas forces, infrastructure facilities and stockpiles of materiel to draw upon to support the deployment of forces to expeditionary missions in a "hub and spoke" manner. [310] The Army of Tomorrow's sustainment requirements will also continue to be achieved by a combination of military administration and civilian support. Civilian support shall include support provided by host nations, other government departments, civilian agencies and domestic and international contractors. From a strategic perspective, there will need to be

310 Colonel F. M. Boomer, "Operational Support Hubs: Global Reach for the Canadian Forces," discussion paper for Commander Canadian Operational Support Command (CANOSCOM), Ottawa, 28 August 2006.

an identified industrial base with the capacity and technical ability to sustain and react to the demand for combat supplies and equipment losses.

Interoperability. The United States is the most likely nation to lead international alliances or coalitions involving Canada for the foreseeable future. Considerable effort shall be required to maintain interoperability with their forces in information exchange, equipment, doctrine, operating procedures and sustainment. On the other hand, Canada must also be prepared to act unilaterally, or participate in a coalition of non-traditional partners, in the furtherance of our national interests. The participation of Canadian joint forces in alliance or coalition operations will usually be defined by reaching agreement on the alliance or coalition force structure and interdependent support arrangements. The command and sustainment of Canadian elements will continue to remain a Canadian responsibility, and unique sustainment support will continue to be required, mostly through the Canadian pipeline.

Description of Required Capabilities by Function

The operational function of Sustain addresses issues of sustainment on the physical and moral planes, or if you will, in the physical, information and cognitive domains. It integrates the provision of materiel and personnel support with the objective of sustaining combat power. It coordinates and focuses the strategic, operational and tactical levels toward the attainment of the mission. What follows is a portfolio of Army of Tomorrow sustain capabilities.

Sustainment Management System. The Adaptive Dispersed Operations Operating Concept requires a sustainment management system that is a complete resource and information management system, including the means to track and control all sustainment assets and processes in an integrated fashion. It must include total asset visibility and a network-enabled command and control system and be deployable and adequately hardened and protected.

- **Total Asset Visibility**. The total asset visibility capability shall consist of tracking, positional awareness, and condition reporting and vetronics capabilities.
    - Tracking. Ubiquitous RFID use should be vigorously pursued in concert with Canadian Operational Support Command (CANOSCOM).
    - Positional Awareness. The positional awareness system for combat service support vehicles and personnel in the battlespace must be similar to and integrated with that for the supported forces. Additionally, materiel tracking systems and positional awareness systems need to be linked in order to provide real-time asset status.
    - Condition Reporting and Vetronics. Prediction of commodity and maintenance requirements, and the ability to respond quickly to urgent situations will be greatly enhanced by the use of sensors built into vehicles, weapons and other equipment, or attached to individual soldiers, which monitor and send critical vehicle component, ammunition use or medical status in real-time on the network.
- **Command and Control**. The command and control capability shall consist of network-enabled digitized communications, collaborative planning and asset control and

management capabilities. It must be integrated with the system of the supported force as well as those of the operational and strategic sustainment systems.

- Digitized Communications.
- Collaborative Planning.
- Asset Control and Management.

Distribution System. The Adaptive Dispersed Operations Operating Concept requires a distribution system that consists of appropriately configured and manned land- and air-based distribution fleets in adequate numbers (including logistics variants of FFCV) integrated as a system and with the sustainment management and materiel systems, from the strategic to tactical levels. This system must be fully capable of automated container handling at all levels, incorporating some autonomous delivery means, and be deployable and adequately hardened and protected.

- **Land-Based Transportation**. The land-based transportation capability shall consist of the Medium Support Vehicle System (MSVS), the Armoured Heavy Support Vehicle System (AHSVS) and the family of future combat vehicles support variants. Some capabilities, such as the MSVS and AHSVS, are in the process of being procured.
  - **MSVS**. MSVS will be the mainstay ground transportation fleet for distribution—other fleets such as the MLVW, HLVW, and most especially, the LSVW should now be withdrawn from use when the security threat level in an area of operation is above negligible.
  - **FFCV Variants**. The FFCV variant, general purpose armoured vehicle, with a suitable trailer should be considered as the vehicle of choice for the integral transport resource requirement.
- **Air-Based Transportation**. The air-based transportation capability shall consist of tactical air lift, aviation and aerial delivery.
  - **Tactical Air Lift**. There will continue to be an increasing requirement for tactical air lift in support of land force sustainment operations, both at the tactical and operational levels.
  - **Aviation**. There is a requirement for medium lift aviation capability in support of medical evacuation and tactical replenishment activities in support of the land force.
  - **Aerial Delivery**. There is an opportunity to provide a significant and immediate increase to distribution capability and delivery options through the procurement of the latest generation of precision aerial delivery systems. The Air Force and the Canadian Forces Land Advanced Warfare Centre have worked together to trial the Canadian Joint Precision Aerial Delivery Standoff Systems based on the MMIST Inc. Sherpa 2200. Up to 16 one-metric ton loads can be quickly delivered from a single C-130 flight with reliability and precision, day or night, in all weather and from significant vertical and lateral standoff distances. This type of capability is envisioned as essential

to the Army of Tomorrow replenishment effort. It is a matter of quantifying how much is needed.

- **Containerization**. The use of standard container configurations—20 foot containers, bi-cons, tri-cons and quad-cons—should eventually be the norm for distribution from the strategic to the lowest tactical levels. Standard configurations for delivery loads should be anticipated and built as early as possible in the supply distribution chain. MSVS, MSVS trailers and FFCV trailers should be able to handle containers as part of their design.

Materiel System. The Adaptive Dispersed Operations Operating Concept requires a materiel system that consists of all of the materiel resources, supply and food services personnel, stock controls and facilities necessary to support the force. It must be integrated as a system and with the sustainment management and distribution systems, from the strategic to tactical levels, and be deployable, and adequately hardened and protected.

- **Warehousing Facilities**. Warehousing facilities will continue to be required in any envisioned operational theatre. Most stockpiling is likely to take place at relatively static and secure operating bases, sometimes afloat, but there will also be a requirement to stock smaller sustainment nodes along the distribution pipelines to provide rapid responsiveness within the system. At the lowest tactical levels, the containerization of commodities itself will facilitate warehousing.

- **Materiel**. The materiel capability shall consist of the commodities of power, fuel, ammunition, water, spare parts, miscellaneous and rations, and the receipt, storage, issue and trans-loading of supplies (stock control).

  With respect to the materiel capabilities, it is not so much the combat supply commodities alone that are the capability, but rather the whole system that brings a particular commodity to the point of use. Thus, the materiel system is tightly integrated with the distribution system in many cases. As an example, water supply requires sources to be found and the water gathered (geological survey, drilling, bulk storage, etc.), purified (chemical or reverse osmosis water purification), moved about, perhaps packaged if bulk systems are not used, and so on. Power is another complex capability requirement in the battlespace. It consumes by far the largest portion of the sustainment system to provide it in one form or another.[311]

  - **Power**. Power generation and management systems, both large static and smaller portable systems, need significant improvement if the sustainment footprint is to be reduced. A key enabler for the soldier in tactical situations will be an improved, lightweight, centralized, rechargeable battery, energy harvesting and power distribution system carried on the soldier.

311 E.g., approximately 70% of the overall logistics tonnage is for fossil fuel typically required in theatre for US forces, 90% of which goes directly to the provision of electricity, and 90% of that which is for air conditioning. They also go through millions of dollars worth of disposable batteries every day. Technology must enable a better system to provide power in the battlespace (Colin G. Cameron, "Trip Report: 2007 Tactical Power Sources" [Washington, DC. 30-31 January 2007], Emerging Materials Section, Defence Research and Development Canada, Halifax, 5 February 2007).

- **Fuel**. Reformed logistics fuel and a longer-term vision to replace reliance on fossil fuels with alternative energy sources is required.
- **Ammunition**. Ammunition should continue to be produced that is more reliable, environmentally friendly and insensitive to external forces.
- **Water**. Water generation, production, purification, storage, packaging, distribution and holding capacity will continue as an essential capability.
- **Spare Parts**. Repair parts scaling and distribution needs to be rationalized, and adequate amounts pushed forward through the echelon system.
- **Miscellaneous**.
- **Rations**.

- **Food Services**. The food services capability shall consist of food services facilities (including equipment) and refrigeration, as well as feeding policies, meal choices and cooks.
  - Food Services Facilities.
  - Refrigeration.

Land Equipment System. The Adaptive Dispersed Operations Operating Concept requires a land equipment system that consists of the vehicles (including FFCV variants), equipment, personnel, facilities and controls needed to manage, maintain, repair, recover and destroy (in situ) all land equipment. It must be integrated as a system, and with the sustainment management system, from the strategic to tactical levels, capable of forward repair in non-secure areas, and be deployable and adequately hardened and protected. There must also be an emphasis on procuring equipment (such as the FFCV) that is more resilient and easier to maintain and repair.

- Maintenance Facilities.
- **Forward Repair**. The forward repair capability shall consist of vehicle mobile repair teams and ancillary mobile repair teams.
  - Vehicle Mobile Repair Teams.
  - Ancillary Mobile Repair Teams.
- **Recovery**. The recovery capability shall consist of self-recovery, general and specialized recovery and salvage and backloading. Heavy, all-terrain assets may often be required to support a medium-weight force.
  - Self-recovery.
  - General and Specialized Recovery.
  - Salvage and Backloading.

Health Services System. The Adaptive Dispersed Operations Operating Concept requires a health services system that consists of the medical facilities, personnel, vehicles, equipment and materiel necessary to provide preventive medicine, casualty evacuation, medical and dental treatment and health reporting for the force. It must be integrated as a system and with the sustainment management system. It must include a robust ability for forward casualty care and risk management in terms of force protection, legal, operational and moral imperatives such as battlespace and long-term health surveillance and be deployable and adequately hardened and protected.

- **Medical Facilities**.
- **Preventive Medicine**.
- **Casualty Evacuation**. The casualty evacuation capability shall consist of the capabilities of recognizing and assessing, stabilizing and transporting casualties, as well as casualty reporting and the reception plan.
    - Recognizing and Assessing Casualties.
    - Stabilizing Casualties.
    - Transporting Casualties.
- **Medical Treatment**. The medical treatment capability shall include the capability of forward casualty care.
    - Forward Casualty Care.
- **Dental Treatment**.
- **Medical Supplies**.
- **Health Reporting**.

Personnel and Financial Services. The Adaptive Dispersed Operations Operating Concept requires a personnel and financial services capability that consists of the necessary financial and personnel support services for the force, including financial services, personnel administration, mortuary services, chaplains, legal services, postal services and amenities. It must be integrated as a system and with the sustainment management system. It must be deployable, and adequately hardened and protected.

- **Financial Services**.
- **Personnel Administration**.
- **Mortuary Services**.
- **Chaplains**.
- **Legal Services**. Legal services include military police services with respect to discipline of personnel.

- **Postal Services**. Though postal services have traditionally been grouped with the supply system, they are presented here as part of personnel services associated with amenities and the maintenance of morale. Mail is not strictly a commodity as it is not fungible.

- **Amenities**. A capability to provide amenities to Canadian Forces personnel will consider such things as CANEX and the wide range of Personnel Support Programs (sports, recreation, health promotion, insurance and financial services, library, messes and non-public funds, etc.), Internet and electronic mail access, long-distance telephone service, leave and vacation planning assistance and satellite television.

Force Generation. The Adaptive Dispersed Operations Operating Concept requires a force generation capability that consists of those enablers necessary for the sustainable and effective generation of deployable forces for operations in the future security environment. The most important aspects of this capability are institutional force generating structures such as the personnel system and the organizational structures of land force areas, brigade groups and units, the training system, institutional consideration of the human dimension and a robust research and development program.

- **Institutional Force Generating Structures**. Institutional force generating structures include the personnel system and organizational structures such as land force headquarters, formations and units, including the Reserve Force.

- **Training System**.

- **The Human Dimension**.

- **Research and Development**.

Force Projection. The Adaptive Dispersed Operations Operating Concept requires a force projection capability that consists of the strategic assets necessary to deploy, sustain and recover forces anywhere in the world. It must include strategic airlift, fast shipping, air and sea ports of disembarkation, sea-based logistics and strategic sustainment assets such as a national sustainment base, strategic lines of communication and theatre sustainment.

- **Strategic Sustainment**. The strategic sustainment capability shall consist of a national sustainment base, strategic lines of communication and theatre sustainment.

    - **National Sustainment Base**.

    - **Strategic Lines of Communication**. Strategic lines of communication include hub and spoke support bases and reception, staging, onward movement and integration (RSOMI).

    - **Theatre Sustainment**. Theatre sustainment will normally include high levels of contractor support, host nation support and movements support.

- **Strategic Airlift**.

- **Fast Shipping**.

- **Air and Sea Ports of Disembarkation**.
- **Sea-Based Logistics**.

Sustainment Force Employment

The Adaptive Dispersed Operations Operating Concept requires a sustainment force employment capability that consists of those enablers necessary for the sustainable and effective employment of land forces in a joint, interagency, multinational and public theatre of operations in the future security environment. The most important aspects of this capability are an integrated echelon system for the provision of sustainment, operational-level sustainment engineering and interoperability and information exchange with security partners.

- **Integrated Echelon System**. The echelon system embodies the command and support relationships, resources and force employment structures starting from the joint operational level down to the lowest independently tasked tactical level. Support to the force is a command responsibility and thus requires that sufficient resources to control the provision of combat service support be apportioned to each and every level. Rationalization of support resources shall not come at the expense of assurance of support to the force. The notion that the land forces will train and fight with the complete range of task-tailored integral, close and general support resources shall remain the doctrinal model. This requirement in no way takes away from the fact that all leaders of combat service support elements must exercise innovation and creativity in approaches to providing effective support in an economical fashion. There may continue to be situations in which radical reorganization and centralization of support assets is called for in the name of efficiency, but a thorough risk analysis shall be undertaken, and all relevant contingencies considered, before assurance of support to the force is jeopardized.

  The focus of the provision of combat service support shall clearly be to the battle group or other units conducting deployed operations in a theatre of operations, as well as to any Canadian land formation and joint task force national command and support elements. Integral to all potentially tasked units will be a core of A and B echelon resources capable of being augmented in a rapid and task-tailored fashion during, or in preparation for, operations. The combat service support or administration company shall be an integral part of a battle group or other unit and shall be task-tailored with augmentation to provide sufficient integral support for “road to high readiness” training and throughout the entire operational deployment and redeployment cycle.

  Adaptive dispersed operations in the future security environment will continue to emphasize relatively independent operations at the sub-unit level and below. This operating concept calls for an increasingly robust sustainment system at the lowest levels. The A1 echelon is the only available resource upon which the sub-unit can draw for immediate support and F echelon personnel replacements due to casualties. While the A1 echelons shall continue to contain a sufficient core of combat arms corps personnel trained in the specific functions undertaken, there shall also be sufficient capability within the combat service support or administration company to provide A1 echelon resources and technical personnel from the functional service support branches. Due to the greater

dispersion of forces expected in the future security environment, it is not unimaginable that double the mobile repair team, ambulance and transportation resources will be required for an Army of Tomorrow sub-unit than for one designed to fight the Cold War.

- **Engineering Support**. An engineering support capability shall include accommodations, construction engineering, waste management, roads and grounds and fire services.

- **Interoperability**. Information exchange and the shared use of strategic and operational sustainment resources are key to operating in an alliance or coalition.

Application and Integration of Sustainment Concepts and Capabilities

Concepts. The notion of sustainment is one that is integral to the Canadian Forces' Strategic Operating Concept. With respect to its relationship to the overall operating concept found in *Land Operations 2021—Adaptive Dispersed Operations: A Force Employment Concept for Canada's Army of Tomorrow*, this functional operating concept of sustainment for Canada's Army of Tomorrow stands as a fully integrated component alongside the other operating, functional, integrating and enabling concepts. At the tactical and operational levels, it represents a core capability area—focused logistics. At the strategic level, sustainability also encompasses many aspects of force generation and national policy, much of which can only be treated in brief fashion in this document. Over the course of time, this concept will need ongoing formulation of supporting concepts, doctrine, structures, requirements projects and other capability development activities in order to remain relevant.

This concept, and the other functional, integrating and enabling concepts supporting *Land Operations 2021—Adaptive Dispersed Operations: A Force Employment Concept for Canada's Army of Tomorrow*, have been developed in accordance with the Army's Capability Development Process.[312] They all constitute an important part of the "Conceive" pillar and are supported by experimentation,[313] operational research and analysis, as well as by decisions reached by the Army Capability Development Board and other approving authorities. The capability gap between today's Army and what is envisioned for the Army of Tomorrow, and the portfolio of capabilities to be developed, will continue to be refined as the various capability development records proceed through the "Design," "Build" and "Manage" pillars.

The hierarchy of concepts that forms the basis for the force employment concept of *Land Operations 2021* starts at the top with the operating concept known as adaptive dispersed operations. Subordinate to this are a series of functional concepts: agility, network enabled, the soldier, integrated effects and sustainment. Beneath these in the hierarchy are a number of enabling concepts: omni-dimensional shield, joint-interagency-multinational-public, command, fusion and knowledge management, the human dimension, the network, full-spectrum engagement, joint fires support, distributed autonomous systems, focused logistics and the Army of Tomorrow battle group.

It is the functional concept of sustainment that is given substance in this document. Because it deals with the entirety of what, in today's lexicon, is an operational function—Sustain—and

312 http://lfdts.kingston.mil.ca/web_temp/DGLCD/02_Mission_&_CD_Continuum/02_Capability_Development_Continuum//Capability_Development_(b).ppt.

313 Army Experiment 9 series.

because this topic is broad enough to contain a number of subordinate functions in its own right, it has been termed a functional operating concept. This functional concept is also integrated into the Adaptive Dispersed Operations Operating Concept by its contribution to the realization of the functional concept agility and through its reliance on the contribution of the network-enabled and the soldier functional concepts. This functional operating concept of sustainment for the Army of Tomorrow has as its core the enabling concept of focused logistics. This enabling concept—Focused Logistics—describes the minimum core of capability sets needed to implement the theatre sustainment requirements of Canada's Army of Tomorrow in the future security environment.

Capabilities. Well prepared soldiers, networked sustainment planning tools and specialized delivery methods are the basis for a focused logistics capability. A focused logistics capability will contribute to the relevance, agility and decisiveness of the force through the sufficient provision of combat service support with the highest level of certainty. It will put the right support in the right place at the right time. It will depend on the global projection of capabilities tailored to all envisioned tasks and shall include total information management and precision service delivery capabilities that are technologically advanced, well protected, economical and sustainable. Thus, all functions and capabilities contributing to an overall focused logistics capability shall support the Canadian Forces' Strategic Operating Concept and its subordinate concepts and supporting capabilities.

The key capabilities leading to an overall focused logistics capability have their nexus in organizational and institutional structures (the echelon system, training and force generation), the traditional combat service support functions (medical, electrical mechanical engineering, supply, transportation, finance, personnel administration, engineering support, etc.) and emerging concepts such as the network, the soldier, the human dimension and knowledge management. The true cost of all of these enablers must be balanced not just against each other as part of a joint sustainment package but as part of an overall strategic capability in support of the interests of the nation of Canada. Pursuing a smart and rigorous capability development process, and leveraging technology and the best that the pure, applied and social sciences research has to offer, will be necessary to develop sustainment capability for the Canadian Forces that respects the special trust that the Canadian public has for this institution.

Conclusions

Sustainment of Army of Tomorrow forces in the future security environment will place extreme demands upon combat service support units and elements. Adaptive dispersed operations will require a highly integrated, adaptive and flexible sustainment system capable of regrouping while sustainment of a number of lines of activity is in progress, with no break in battle rhythm. The sustainment system must be internally integrated at all levels and between all functions. It must also remain integrated with the other operational functions, especially during planning for combat operations. Thus, for adaptive dispersed operations, combat service support elements shall be trained and equipped to work, fight and survive in a non-linear, non-contiguous, asymmetric and dangerous battlespace alongside combat and combat support arms.

The embodiment of agility is realized through training and deploying land forces based on a force employment structure with a specifically defined level of tactical self-sufficiency, including the inherent ability to adapt to a diverse set of circumstances in complex terrain and a large area of operations. But, sustainment will also continue to be a major determining influence on the tempo of operations possible by the joint force. Thus, while there is a necessity to optimize the sustainment footprint, this cannot be done at the expense of the agility and sustained combat power of the forces employed on operations and shall not outstrip the ability of technology and finances to provide the capability offsets which can make up for combat service support reductions.

The Army of Tomorrow battle groups and formations will employ all five operational functions, including Sustain, in a balanced and integrated manner, allowing for the conduct of a wide range of necessary tasks across the spectrum of conflict. Rapidly deployable joint task forces shall be capable of independent action or working within a coalition or alliance, whether in a domestic or international setting. The ability to quickly disperse and concentrate forces within the area of operations is the key to the adaptivity required by the land component.

It is imperative for the Army of Tomorrow to have the capability to deal with the principal characteristics of the future security environment: rapid change, uncertainty, complexity and lethality. Commanders must be able to conduct simultaneous operations in a joint, interagency, multinational and public context while retaining the flexibility to respond to emerging or unforeseen crises. Flexibility is a key to sustaining a high tempo of operations and seizing the initiative across a range of military operations. This will ensure that the Army of Tomorrow can act swiftly and decisively throughout the continuum of operations and achieve the necessary effects in the future security environment.

Recommendations

1. The Army of Tomorrow shall have its combat service support organized into appropriate echelons delivering clearly defined integral, close and general support on operations and while training for operations. Battle groups and other deployable units such as reconstruction teams shall include a task-tailored A echelon which provides integral support. This would normally be in the form of a combat service support company (traditionally known as an administration company). This company will also include sufficient combat service support assets that can then be grouped as necessary as part of sub-unit A1 echelons, providing immediate support to the force.

2. Close support shall be provided to dispersed units or other formation elements, normally, by means of forward support groups constituted as required from a joint task force support element on international operations during high-readiness training and from the force generating service battalion or support group during routine training and domestic operations. General support, and all support to formation or other elements not dispersed, shall come from static installations found in garrison or relatively secure base areas.

3. A fully network-enabled sustainment information management system shall be instituted, to include total asset tracking and visibility capability and the planning tools required to provide focused logistics to the force.

4. The core of the Land Force Sustainment System capability shall reside in the land-based echelons. They will have, down to the lowest levels, networked access to the sustainment information management system. They shall be equipped with vehicles providing comparable mobility and protection to the elements they are supporting and which account for the future security and operating environment (i.e., comparable to the family of future combat vehicles). They shall also be adequately armed and trained in the applicable tactics, techniques and procedures so that they can provide a sufficient level of self-defence. Maximum use will be made of containerization and preconfigured loads, forward repair, forward casualty care and rapid evacuation by air or aviation as the need arises.

5. The latest generation precision aerial delivery means shall be procured in sufficient quantity to provide the capability of some routine and emergency replenishment to dispersed forces.

6. Emerging technologies must be aggressively pursued in the attainment of increased protection, reliability, economy and the reduction of the sustainment footprint, especially with respect to personnel health and safety, vehicle and equipment maintenance, repair and recovery and the consumption of fuel, power, spare parts, ammunition, food and water.

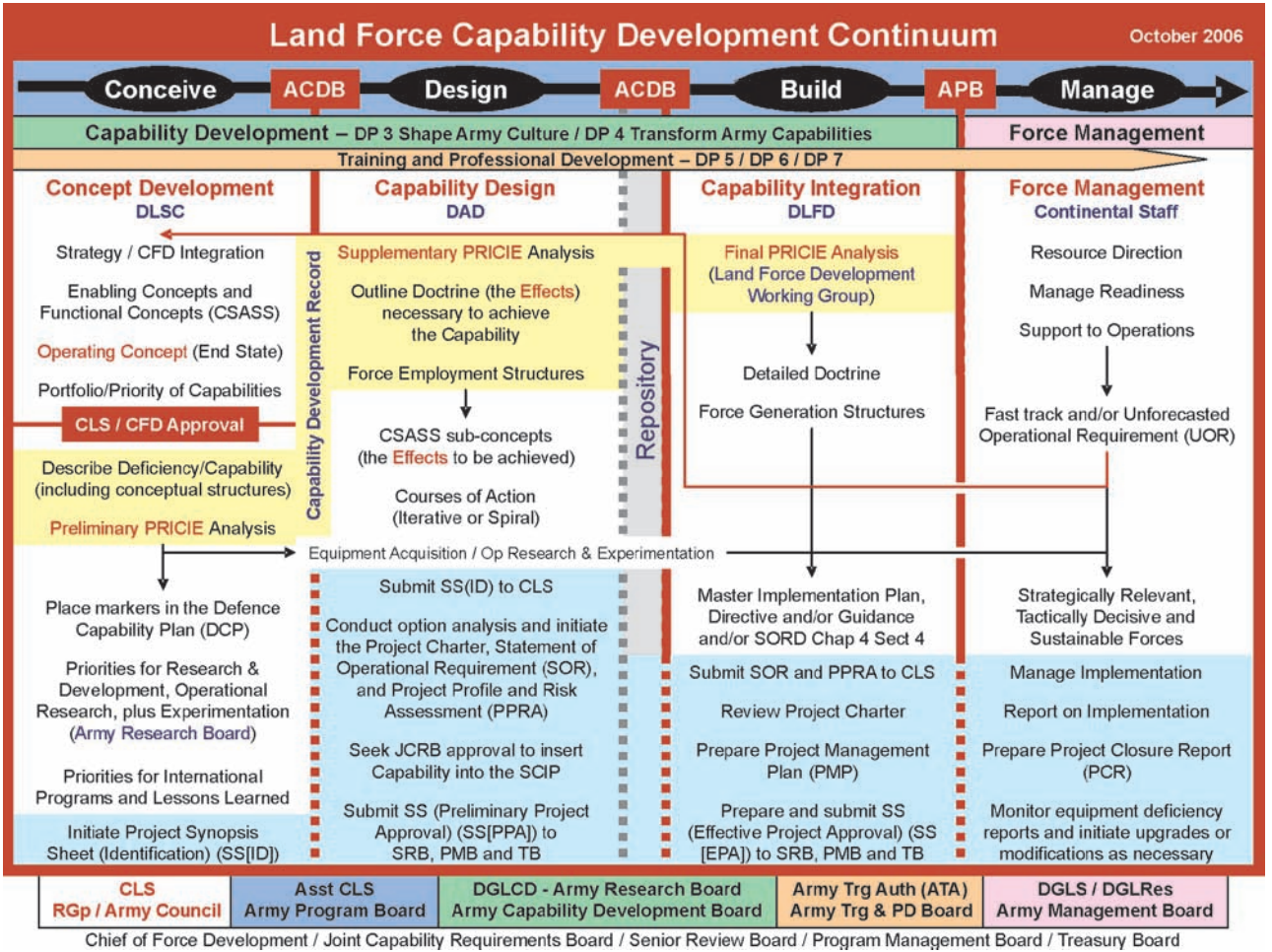
This functional operating concept of sustainment for the Army of Tomorrow is adaptable to the conduct of a wide range of land operations and has a high likelihood of remaining valid in the future security environment for some time. It is compatible with other land force, joint and strategic operating concepts. While it recognizes the incremental and political nature of institutional capability procurement practices, it is based upon the acceptance of a transformational vision for the future of the Canadian Forces.

The capability requirements of this concept shall continue to be further refined through an aggressive program of experimentation and operational research and analysis. The optimum force structure and equipment scales are predictable if reliable consumption data are provided and operating conditions are modelled adequately. This concept, while put forth with a high level of confidence, is meant to be a point of departure for further discussion and debate rather than a definitive prescription on the future of sustainment in the Army.

Appendix A

Capability Development and the Canadian Army: An Overview

The current systems approach to Army capability development had its genesis in the mid 1980s but was refined and modernized during the 1990s to switch from a threat-based to a capability-based approach to development. This process was adopted to allow for the logical and sequential development of land warfare capabilities needed for the challenges of today and tomorrow. The following diagram illustrates how this process functions.


Land Force Capability Development Continuum
October 2006
Conceive
ACDB
Design
ACDB
Build
APB
Manage
Capability Development – DP 3 Shape Army Culture / DP 4 Transform Army Capabilities
Force Management
Training and Professional Development – DP 5 / DP 6 / DP 7
Concept Development
DLSC
Capability Design
DAD
Capability Integration
DLFD
Force Management
Continental Staff
Strategy / CFD Integration
Enabling Concepts and Functional Concepts (CSASS)
Operating Concept (End State)
Portfolio/Priority of Capabilities
CLS / CFD Approval
Describe Deficiency/Capability (including conceptual structures)
Preliminary PRICIE Analysis
Capability Development Record
Supplementary PRICIE Analysis
Outline Doctrine (the Effects) necessary to achieve the Capability
Force Employment Structures
CSASS sub-concepts (the Effects to be achieved)
Courses of Action (Iterative or Spiral)
Repository
Final PRICIE Analysis (Land Force Development Working Group)
Detailed Doctrine
Force Generation Structures
Resource Direction
Manage Readiness
Support to Operations
Fast track and/or Unforecasted Operational Requirement (UOR)
Equipment Acquisition / Op Research & Experimentation
Place markers in the Defence Capability Plan (DCP)
Priorities for Research & Development, Operational Research, plus Experimentation (Army Research Board)
Priorities for International Programs and Lessons Learned
Initiate Project Synopsis Sheet (Identification) (SS[ID])
Submit SS(ID) to CLS
Conduct option analysis and initiate the Project Charter, Statement of Operational Requirement (SOR), and Project Profile and Risk Assessment (PPRA)
Seek JCRB approval to insert Capability into the SCIP
Submit SS (Preliminary Project Approval) (SS[PPA]) to SRB, PMB and TB
Master Implementation Plan, Directive and/or Guidance and/or SORD Chap 4 Sect 4
Submit SOR and PPRA to CLS
Review Project Charter
Prepare Project Management Plan (PMP)
Prepare and submit SS (Effective Project Approval) (SS [EPA]) to SRB, PMB and TB
Strategically Relevant, Tactically Decisive and Sustainable Forces
Manage Implementation
Report on Implementation
Prepare Project Closure Report (PCR)
Monitor equipment deficiency reports and initiate upgrades or modifications as necessary
CLS
RGp / Army Council
Asst CLS
Army Program Board
DGLCD - Army Research Board
Army Capability Development Board
Army Trg Auth (ATA)
Army Trg & PD Board
DGLS / DGLRes
Army Management Board
Chief of Force Development / Joint Capability Requirements Board / Senior Review Board / Program Management Board / Treasury Board

AC—Army Council

ACDB—Army Capability Development Board

AEC—Army Experimentation Centre

AFDC—Air Force Development Committee

AFROCCC—AF R&D, OR, CD&E Coordinating Committee

ALLC—Army Lessons Learned Centre

APB—Army Program Board

ARB—Army Research Board

ATA—Army Training Authority

ATPDB—Army Training and Professional Development Board

ATP—Army Terminology Panel

CBP—Capability Based Planning

CDB—CF Capability Development Board

CD&E—Concept Development and Experimentation

CDORT—Capability Development OR Team

CDR—Capability Development Record

CFD—Chief of Force Development

CFEC—Canadian Forces Experimentation Centre

CLS—Chief of the Land Staff

COA—Course of Action

CSASS—Command, Sense, Act, Shield and Sustain

DAD—Director Army Doctrine

DCP—Defence Capability Plan

DGLCD—Director General Land Capability Development

DGLRes—Director General Land Reserves

DGLS—Director General Land Staff

DLFD—Director Land Force Development

DLR—Director Land Requirements

DLSC—Director Land Strategic Concepts

DLSE—Director Land Synthetic Environments

DMS—Defence Management System (in order performed):

SS(ID)—Synopsis Sheet (Identification) / **PPRA**—Project Profile and Risk Assessment/ **SS(PPA)**—Synopsis Sheet (Preliminary Project Approval) / **PMP**—Project Management Plan / **SS(EPA)**—Synopsis Sheet (Effective Project Approval) / **SOR**—Statement of Operational Requirement / **PCR**—Project Closure Report

DSG—Defence Strategic Guidance

FE / FG—Force Employment / Force Generation

FSE—Future Security Environment

JCPT—Joint Capability Planning Team

JCRB—Joint Capability Requirements Board

LFCR—Land Force Capability Release

LFDTS—Land Force Doctrine and Training System

LFDWG—Land Force Development Working Group

LFSWG—Land Force Structures Working Group

LL—Lessons Learned

LPCP—Land Personnel Concepts and Policies

MIP—Master Implementation Plan

MRP—Managed Readiness Plan

OR—Operational Research / ORE – OR and Experimentation

PMB—Program Management Board

PRICIE—Analytical framework

R&D—Research and Development

RGp—CLS Reconnaissance Group (Selected senior staff)

SOC—Strategic Operating Concept

SORD—Strategic Operations and Resource Direction

SRB—Senior Review Board

TB—Treasury Board

UOR—Unforecasted Operational Requirement

Appendix B

Capability Hierarchy and Portfolio

The Directorate of Land Concepts and Designs conducted a capability gap analysis in conjunction with the initial distribution of Land Operations 2021—Adaptive Dispersed Operations: A Force Employment Concept for the Army of Tomorrow. It was done primarily in order to support the initiation of capability development records for the "Conceive" pillar of the Land Force Capability Development Process. The aim was to produce: a set of well-articulated concepts in a companion book to the force employment concept; a set of required Army of Tomorrow capabilities in a hierarchy; common-language for the capability descriptions; allocation by operational function of "capability clusters" for the staffing of the capability development records; and initiating the preliminary PRICIE analysis.

In order to jump-start some of the concept development in potentially crucial areas, there were three special studies commissioned to pursue the following lines of investigation: family of future combat vehicles; optimized battle group structures; and joint, interagency, multinational and public (JIMP) environment enablers for the battle group headquarters. Some of the spin-off products of these studies and the gap analysis are a supporting operational research and experimentation plan, Defence Capability Program markers, equipment priorities and the affiliated battle group experiment directive. All of this work was done in coordination with the strategic joint level efforts of the Chief of Force Development organization.

The following framework constitutes the Army of Tomorrow capability development hierarchy and portfolio of capability clusters.

Command

Command and Control System

- Information system and backbone
- JIMP-focused staff, including liaison
- Mobile, modular command post system (enhanced battle-view)
- Balanced virtual and physical presence of the commander
- Airborne command and control
- Air and ground reconnaissance
- Common voice and data communication system
- High-level battlefield visualization or situational awareness
- Horizontal and vertical information management system
- Embedded modelling and simulation system
- Threat awareness system
- On-the-move synchronization (beyond-line-of-sight radios, satcom)
- Failsafe and backup mechanisms

Decision and Planning Support System

- Information system and backbone
- Information display with man-machine interface
- Physical and network protected systems
- Software to support automated and streamlined decision support
- Collaborative planning tools
- Modular design
- Failsafe and backup mechanisms
- Protected database
- Situation knowledge of JIMP partners
- Sense feeds on enemy disposition
- Red-teaming capability
- Sustainment posture information
- Automated operational planning process

The Network

- People
  - Informed and technically competent
  - Effective within a JIMP environment, both domestic and international
  - Full connectivity with liaison officers
  - Moral and ethically astute
  - Knowledgeable in the laws of war and rules of law
- Processes
  - Network vertically and horizontally, integrated from strategic to tactical level
  - Updated information sharing and management practices
- Information Systems
  - A layered, survivable, self-configuring, self-healing system with no single point of failure
  - Combination of machines providing a single, integrated network which is fully integrated with the global information grid

JIMP Connectivity

- Infrastructure (databases, communications and tools) that assist networked operations management and planning at the appropriate level
- Security protocols that allow for the sharing of information and intelligence between JIMP partners
- Human as well as digital interface will be a key factor with force generation implications through education and training

Battlespace Understanding

- Direction collection coordination intelligence requirements management (CCIRM)
  - Planning and assessment tools
  - CCIRM and request for information tools
  - Intelligence, surveillance and reconnaissance synchronization and display tools
  - Distributed collaboration
- Collection of Battlespace Information
  - Find, fix, track and target full-spectrum threats
  - Collect within urban structures
  - Collect friendly and enemy situational awareness
  - Collect within sub-surface locations
  - Maintain red, brown and white situational awareness
  - Collect socio-cultural and institutional information
  - Collect infrastructure information
  - Collect indigenous population situational awareness
  - Maintain JIMP situational awareness
- Processing / Data Fusion / Knowledge Management
  - Collation
  - Evaluation
  - Analysis
  - Integration
  - Interpretation
- Dissemination
  - Oral
  - Written
  - Graphic

Adaptive Dispersion

- FFCV
  - Light vehicles
  - Light armoured vehicles
  - Medium armoured vehicles
  - Unmanned air vehicles
  - Unmanned ground vehicles
  - Line-of-sight, beyond-line-of-sight and non-line-of-sight fire support
  - System of systems integration
- Full-Spectrum Engagement
  - Operational manoeuvre
  - Tactical manoeuvre
  - Close engagement
- Integrated Effects
  - Adaptive forces capable of coordinated dispersion and aggregation

    - A robust and resilient network that encompasses a common operating picture, producing a level of situational awareness that fosters initiative, collaboration and coordination
    - Networked land-, air- and sea-based sensor, weapon and command and control systems that combine to provide the force with a mix of lethal and non-lethal area and precision options for engaging the adversary
- The Integrated Soldier
    - Networked situational awareness
    - Precision navigation
    - Data storage and retrieval
    - Target acquisition
    - Connectivity with other soldiers, leaders, sensors, vehicles and weapons
    - Collaborative planning
    - Coordinated mission execution

Omni-Dimensional Shield

- Shielding from chemical, biological, radiological, nuclear and environmental threats and hazards
    - Shielding from chemical threats
        - Prevent and predict
        - Detect
        - Contain and neutralize
    - Shielding from biological threats
        - Prevent and predict
        - Detect
        - Contain and neutralize
    - Shielding from radiological threats
        - Prevent and predict
        - Detect
        - Contain and neutralize
    - Shielding from nuclear threats
        - Prevent and predict
        - Detect
        - Contain and neutralize
    - Shielding from environmental and occupational health and safety hazards
        - Prevent and predict
        - Detect
        - Contain and neutralize
- Shielding from aerial threats
    - Prevent and predict
    - Detect

    - Contain and neutralize
- Shielding from psychological threats
    - Prevent and predict
    - Detect
    - Contain and neutralize
- Shielding from direct kinetic threats
    - Prevent and predict
        - Personnel
        - Vehicles
        - Equipment
        - Activities
        - Facilities
    - Detect
        - Personnel
        - Vehicles
        - Equipment
        - Activities
        - Facilities
    - Contain and neutralize
        - Personnel
        - Vehicles
        - Equipment
        - Activities
- Shielding from fratricide
    - Visual identification system
    - Identification friend or foe system
    - Recognition training system
    - Automated signature recognition system
    - Blue emitter system (linked to the network)
    - Doctrine, tactics, techniques and procedures, standing operating procedures and rules of engagement
    - Automated rules of engagement system (linked to the network)
    - Rules of engagement automated training system

Focused Logistics

- Sustainment Management System
    - Total asset visibility
        - Radio frequency identification tracking
        - Positional awareness
        - Condition reporting and vetronics
    - Command and control

        - Digitized communications
        - Collaborative planning
        - Asset control and management
- Distribution System
    - Land-based transportation
        - Medium support vehicle system
        - Family of future combat vehicle variants
    - Air-based transportation
        - Tactical airlift
        - Aviation
        - Aerial delivery
    - Containerization
- Materiel System
    - Warehousing facilities
    - Materiel
        - Power
        - Fuel
        - Ammunition
        - Water
        - Spare parts
        - Miscellaneous
        - Rations
    - Food services
        - Food services facilities
        - Refrigeration
- Land Equipment System
    - Maintenance facilities
    - Forward repair
        - Vehicle mobile repair teams
        - Ancillary mobile repair teams
    - Recovery
        - Self-recovery
        - General and specialized recovery
        - Salvage and back-loading
- Health Services System
    - Medical facilities
    - Preventive medicine
    - Casualty evacuation
        - Recognizing and assessing casualties
        - Stabilizing casualties
        - Transporting casualties

    - Medical treatment
        - Forward casualty care
    - Dental treatment
    - Medical supplies
    - Health reporting

- Personnel and Financial Services
    - Financial services
    - Personnel administration
    - Mortuary services
    - Chaplains
    - Legal services
    - Postal services
    - Amenities

Joint Operational and Strategic Issues

- Force Generation
    - Institutional force generating structures
    - Training system
    - The human dimension
    - Research and development
- Force Projection
    - Strategic sustainment
        - National sustainment base
        - Strategic lines of communication
        - Theatre sustainment
    - Strategic airlift
    - Fast shipping
    - Air and sea ports of disembarkation
    - Sea-based logistics
- Sustainment Force Employment
    - Integrated echelon system
    - Interoperability
    - Engineering support

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