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CP140 AURORA INCREMENTAL MODERNIZATION PROGRAM (AIMP):

NOT ENOUGH FOR THE 21st CENTURY

A Thesis Submitted
By

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ABSTRACT

This essay addresses Canadian Forces' Intelligence, Surveillance and Reconnaissance (ISR) requirements in support of the Canadian defence missions. Over the past decade, the American-led Revolution in Military Affairs (RMA) has introduced fundamental changes in the conduct of military operations. A key aspect of these changes is the exploitation of advanced computer, communication, sensor and weapon technologies. Given the significant cost of RMA technologies, Canada must choose wisely which aspects of the RMA it can and should adopt. ISR is an excellent niche capability for Canada as it would contribute immensely to the fulfillment of the Canadian defence missions while providing a meaningful supplementary capability to a coalition force. Canada currently has very few ISR assets and will therefore have to initiate an aggressive acquisition strategy that takes into account Canadian needs and available funds. A proposal involving access to RADARSAT imagery, the acquisition of a limited number of medium altitude unmanned aerial vehicles (UAVs) and the modification of the CP140 Aurora for land and aerospace ISR roles is discussed. The implementation of the proposed acquisition strategy will give Canada a robust surveillance capability for the battlespace of the 21st century.

RÉSUMÉ

Ce travail traite des besoins opérationnels des Forces Canadiennes dans les domaines de l'intelligence, la surveillance et la reconnaissance (ISR). Au cours des dix dernières années, la révolution dans les affaires militaires (RAM) menée par les forces armées américaines a conduit à un bouleversement profond dans la façon dont les opérations militaires sont exécutées. Un des principaux aspects de cette révolution est l'exploitation des technologies de pointes tel que l'informatique, les communications, les capteurs électroniques et l'armement. Dû au coût important associé aux technologies de la RAM, le Canada se doit de choisir avec justesse quelles technologies il doit et peut se permettre. Le domaine de l'ISR représente une excellente niche pour le Canada car il pourrait contribuer grandement à la réalisation de ses objectifs de défense tout en constituant une force additionnelle qui pourrait être mise à la disposition d'une coalition militaire multinationale. À ce moment, le Canada ne possède que très peu d'aéronefs pouvant être utilisés pour des missions du type ISR et devra donc adopter une stratégie chevronnée qui tiendra compte des besoins du Canada ainsi que des fonds monétaires disponibles. Une approche basée sur l'accès continu aux images produites par le satellite RADARSAT, l'achat d'un petit nombre de véhicules aéroportés non-habités et la modification de l'aéronef CP140 Aurora pour le support ISR aux forces terrestres ainsi qu'aux forces aériennes est présentée. Cette proposition devrait fournir au Canada les éléments essentiels d'un système de surveillance robuste bien adapté aux besoins du 21ième siècle.

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"Now the reason the enlightened prince and the wise general conquer the enemy whenever they move and their achievements surpass those of ordinary men is foreknowledge."[1]

- Sun Tzu

I. INTRODUCTION

The current American Revolution in Military Affairs (RMA) has been the subject of numerous discussions in the Western world over the past decade. Simply stated, the RMA is "a rapid change in military technology, doctrine and organization leading to a sweeping new way that wars are fought."[2] Proponents and opponents of the RMA have been engaged in a furious debate over a wide range of issues ranging from technical feasibility and financial affordability to operational effectiveness in military operations other than war. Notwithstanding these issues, the United States (US) Department of Defence (DoD) has decided to embrace the concepts of the RMA as evidenced in its new strategic vision – *Joint Vision 2010/2020* – and has developed an aggressive plan to implement necessary technical, doctrinal and organizational changes.[3]

After a series of high-level conferences and concept papers produced in 1998/1999 as a result of the American RMA initiative, Canada tackled directly the

[1] Griffith, Samuel B. "Sun Tzu – The Art of War." Oxford University Press. London. 1963. 144.
[2] Mets, David R. "The long Search for a Surgical Strike." Air University Press, Maxwell Air Force Base Alabama, 2001. vii.
[3] Joint Vision (JV) 2010 was published in July 1996 followed by an accompanying document - *The Concept for Future Joint Operations* – one year later. These high-level documents were soon followed by key documents produced by each of the four services: the US Army's "Vision 2010", the US Navy's "Forward … from the Sea", the US Marine's "Operational Maneuver from the Sea" and the US Air Force's "Global Engagement: A Vision for the 21st Century." In Neal, Thomas C. "Defining Joint Vision 2010 in Terms of Service Core Competencies." Research Paper US Air Command and Staff College, Maxwell.

concepts of the RMA in a strategic planning document: *Strategic Capability Planning for the Canadian Forces (CF)*.[4] This document identifies key capability areas required by the CF such as command, information and intelligence, mobility and force protection. A further assessment of the impact of the RMA conducted by the Air Force led to the development of *Vectors 2020*, a conceptual document which identifies pursued core competencies. These include control of the air, information exploitation, rapid force mobility and precision engagement. Common to these two assessments is the need to develop an information and intelligence capability. According to Vectors 2020, aerospace information exploitation is "the ability to gather and exploit information … derived from the exploitation of aerospace power (eg. surveillance by manned or uninhabited aircraft and satellites)."[5]

A rapid examination of current CF capabilities in the area of aerospace surveillance reveals a serious deficiency. As reported by Sloan, "a notable capability gap in the Canadian military's RMA technologies is in operational and strategic intelligence gathering, surveillance and reconnaissance capabilities."[6] Canada has no military satellite surveillance system, unmanned aerial vehicles or manned surveillance aircraft equivalent to the American Airborne Warning and Control System (AWACS) or the Joint Surveillance Target Attack Radar System (JSTARS). As a result, "Canada … is almost entirely dependent on the United States for its intelligence collecting, surveillance and

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Mar 1997. 5, 8, 11, 14. It should be noted that JV 2010 was revised and republished in 1997 as JV 2020. http://www.dtic.mil/jv2020/

[4] Canada. Department of National Defence. "Strategic Capability Planning for the Canadian Forces." (Ottawa: DND Canada, Jun 2000). http://www.vcds.dnd.ca/dgsp/dda/strat/intro_e.asp

[5] Canada. Department of National Defence. "Vectors 2020. - DRAFT" (Winnipeg: 1 Canadian Air Division, Fall 2001). No page numbers.

[6] Sloan, Elinor C. "Canada and the Revolution in Military Affairs." Directorate of Strategic Analysis – Policy Planning Division, Policy Group. Project Report No. 2000/14. Jun 2000. 10.

reconnaissance information."[7] Although Canada could theoretically purchase American unmanned aerial surveillance vehicles tomorrow, this would only represent a partial solution to a larger problem. Purchase of a new manned aircraft to fill CF airborne early warning or surface surveillance requirements is clearly not an option given the current fiscal climate.

Over the past twenty years, Canada has relied on the CP140 Aurora long-range patrol aircraft to fulfill its national surface surveillance needs. Although primarily designed for anti-submarine warfare (ASW), the Aurora sensor suite was found well suited for many peacetime land surface surveillance roles. After twenty years of service, the Aurora has now reached the point where its avionics and sensor suite are no longer maintainable and must be replaced. A modernization program – *CP140 Aurora Incremental Modernization Program (AIMP)* - was therefore launched in February 2001 to rectify current deficiencies by replacing existing onboard systems with modern ones. The decision of the Department to restrict the modernization program of the Aurora to a 'restoration of capabilities'[8] could arguably be construed as an indication that the role of the aircraft will remain the same that is, an ASW platform. Given the stated need of the CF for an Intelligence, Surveillance and Reconnaissance (ISR) capability able to operate effectively in an RMA-driven battlespace and the potential of the Aurora as an airborne surveillance platform, it can only be concluded that either the potential of the aircraft or the requirements of the RMA are misunderstood.

This essay argues that the CP140 Aurora is the surveillance platform needed by the CF to fulfill its joint ISR requirements over the next two decades and that the current

[7] Sloan. 10.
[8] Canada. Department of National Defence. "Master Implementation Plan for the CP140 Aurora Incremental Modernization Project (AIMP)." (Ottawa: DND Canada, Feb 2001). 1.

modernization program must be re-examined immediately to take into account Canada's ISR needs. To this end, this essay will start by reviewing the global context and trends that will impact the CF over the next two decades and more specifically, the American-led RMA. An RMA niche capability for Canada will then be identified and discussed followed by an in depth examination of ISR and its relationship to the proposed US 'system of systems'. The essay will then briefly review the current CF ISR capabilities and discuss Canada's ISR requirements. Having identified capabilities and requirements, the essay will finally present and discuss a strategy aimed at closing identified ISR gaps and focused primarily on the modification of the CP140 Aurora to fulfill land and air ISR roles.

This essay will be limited to the examination and discussion of requirements and capabilities and will not address the costs associated with the proposed options. It should be understood however that the intent of this essay is to propose solutions that are politically acceptable, technically feasible and within the financial means of the Canadian Forces.

II. CANADA AT THE DAWN OF THE 21st CENTURY

Following the fall of the Berlin Wall in 1989, nations around the world celebrated the beginning of a new and promising era where military confrontation would give way to a new world order governed by global economic competition. High hopes for a peaceful strategic environment soon vanished as the threat of nuclear holocaust was replaced by global military instability. Political rivalries, ethnic hatred and religious disputes which were dormant during the Cold War period have now surfaced in many parts of the world and started to threaten international stability and security.

It is against this new strategic backdrop that the Canadian Forces must define its new role and plan the development of a new force structure. Equipment, organization and doctrine designed for the Cold War have to be replaced by new ones better suited for the military conflicts of the 21st century. As this self-examination is being conducted, the Canadian Forces must also take into consideration internal and external forces that will impact on its development and evolution over the next twenty-five years. Three of the most important and significant forces that will shape the future of the Canadian Forces are the assigned defence missions, the impact of reduced defence budgets and the participation of Canada in the American-led RMA.

DEFENCE MISSIONS: 2000 - 2025

In the past fifty years, the defence missions assigned to the Canadian Forces have remained essentially the same. Even after the transition to the post-Cold War strategic

environment, those fundamental tasks are still the main focus of defence in Canada. These missions are:

> The defence of Canada and the protection of Canadian sovereignty (including aid to the civil powers);
> The defence of the North American continent in cooperation with the US (through the North American Aerospace Defence (NORAD) agreement); and
> The contribution to international peace and security (through the United Nations (UN) and North Atlantic Treaty Alliance (NATO) organizations).

While the defence missions have remained the same, the priorities or emphasis assigned to each of these missions have been the key variable in Canadian politics. This emphasis has been articulated by the Canadian Government through its foreign policy.

During the period following the Second World War, the threat of a Soviet attack against the West led Canada and Canadian foreign policy to favour national security through alliances. Canada played an important role in the founding of NATO in 1949 and later ratified a bilateral defence agreement with the US – NORAD – in 1958. In the early fifties, foreign policy turned its attention towards global peace and security. As noted by Bashow, "[O]ut of their wartime experience Canadians developed a passionate interest in promoting a global environment in which peace and security could be assured to the extent possible, and attention was focused on the United Nations."[9] This strong national belief led Canada to the creation of the concept of peacekeeping and the conduct of the first peacekeeping mission in 1956.

[9] Bashow, David L. "Reconciling the irreconcilable: Canada's Foreign and Defence Policy Linkage. Canadian Military Journal. Vol 1 No 1 Spring 2000. 2.

In the late 1960's, Canadian foreign policy under Prime Minister Trudeau were significantly revised. According to Nossal, "Trudeau held that Canadian foreign policy no longer served the national interest."[10] A corresponding revision to Canadian defence policies elevated the defence of Canadian sovereignty to the forefront of the defence priority list while downplaying the importance of collective security and the participation of Canada overseas.[11] In 1984, Canadian foreign policies under newly elected Prime Minister Mulroney returned to the concept of collective security. Two Defence White Papers published in 1987 and 1994 by the Mulroney Government projected the concepts of 'stable international environment' and 'global peace' as key to protecting Canadian national security thereby emphasizing the importance of the third defence mission (ie. contributing to international peace and security). These views on foreign policies and defence missions have been shared by the subsequent Chrétien Government as expressed in the 1995 foreign policy paper "*Canada in the World*" and the adoption of the 1994 Defence White Paper.

While the current foreign and defence policies support the concepts of collective security and global peace, the question regarding Canadian Forces future defence missions still remains. Jockel has argued that the "human security" agenda proposed by foreign minister Axworthy in 1999 provides the justification for Canadian Forces interventions overseas.[12] On the other hand, Marsh warned that "future Canadian

[10] Nossal, Kim Richard. "The Politics of Canadian Foreign Policy." Prentice Hall Canada, Scarborough. 1997. 180.
[11] According to Bashow, "[Trudeau] thought that Canada had become obsessed with both Europe and the Soviet-American Cold War struggle." During the period 1968-1975, Canadian Forces personnel overseas were reduced significantly and funds necessary to replace dated equipment in Europe were not made available. 4.
[12] Jockel, Joseph and Sokolski Joel. "Lloyd Axworthy's Legacy: Human Security and the Rescue of Canadian Defence Policy." International Journal. Winter 2000-2001. 2.

societies are likely to be more isolationists and less intrusive in international affairs."[13] A recent Senate report on the implication of the new NATO and the evolution of peacekeeping for Canada concluded that: "… NATO still matters to Canada. Notwithstanding the uncertainty associated with the new NATO and the implications of the emerging European Security and Defence Identity, Canada's continuing engagement in European security within the NATO context represents a necessary complement to our relationship with the U.S. on matters of North American security and defence."[14] On the subject of peacekeeping, the Report indicated that "Canada has a vital contribution to make to peacekeeping and peacemaking around the world."[15]

Given these clear political views and the strong support voiced by Canadians for continued participation in NORAD, NATO and the UN[16], it is reasonable to assume that the defence missions of the Canadian Forces will remain the same for the foreseeable future. The Canadian military will continue its strategic surveillance and defence role over the Canadian territory and will contribute to the defence of the North American continent in collaboration with its southern neighbour, the United States. In the pursuit of Canadian foreign policies, the Canadian Forces will also be called upon to participate in UN and NATO-led military operations aimed at fostering global stability and security. A corollary to these statements is that the Canadian Forces will therefore have to be properly trained and equipped to operate across the full spectrum of potential military

[13] Marsh H.J. "Command Challenges in the Twenty-First Century." In Generalship and the Art of the Admiral edited by Horn and Harris. Vanwell Publishing Limited. 2001. 201.
[14] Canada. "The New NATO and the Evolution of Peacekeeping: Implications for Canada." Report of the Standing Senate Committee on Foreign Affairs. Apr 2000. 24.
[15] Although the report fully supports Canada's participation in UN missions, it also indicates that Canada "must be careful, …, not to be dragged into every conflict where human security is threatened or where the interests of our NATO allies may be engaged." In "The New NATO and the Evolution of Peacekeeping: Implications for Canada". 58.
[16] According to the 2001-2002 Report on Plans and Priorities, 88% of Canadians support continued participation in NORAD, 85% have a favourable attitude towards NATO and 88% support the use of force

conflicts ranging from peacekeeping and humanitarian assistance operations to peace enforcement and war. The implications of the new strategic environment on Canadian defence policies are clearly articulated in Defence Planning Guidance 2001: "If Canada is to continue to work for the well-being of Canadians and international peace and security, it must have modern, combat-capable, multi-purpose and globally deployable forces, properly equipped with advanced capabilities that target leading edge doctrine and technologies relevant to the 21st century."[17]

IMPACT OF REDUCED DEFENCE BUDGETS

Although the end of the Cold War and the transition to a new strategic environment have probably been the most significant events in the past decade, they were by no means the only global forces which have impacted Western countries. After decades of governmental overspending and financial mismanagement, many Western countries approached the end of the century with large accumulated national debts consuming significant portions of their national budget. In order to reduce the national debt and gain better control over public finances, the Canadian federal government has initiated in the early 1990's a number of drastic measures aimed at reducing federal spending. This expenditure reduction program has meant significant cuts in most area of spending including defence. During the 1994 to 1998 period, the defence department has seen its annual budget reduced by approximately 30 percent[18], resulting in a significant

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to support peace operations. In Canada. Department of National Defence. "2001-2002 Report on Plans and Priorities" (Ottawa: DND Canada, 2001). 3.

[17] Canada. Department of National Defence. "Defence Planning Guidance 2001". (Ottawa: DND Canada, 2000). Art 105.

[18] The Government-wide program review initiative reduced defence spending by 23% (30% in real terms) from $12 billion in 1993-1994 to $9.38 billion in 1998-1999. In Canada. Department of National Defence. "1999-2000 Report on Plans and Priorities." (Ottawa: DND Canada, 2000). 6.

cut to department personnel[19] and a corresponding reduction in its supporting base infrastructures.

Five years after the last budget cut was announced, the department of defence is still struggling to balance personnel, operations, maintenance and acquisition expenses. Furthermore, growing concerns over the effectiveness and maintainability of aging equipment are pressuring the department into seriously considering replacement. Achieving a balance between competing demands while carrying out a needed equipment replacement program will clearly become an enormous challenge. Assuming no changes in defence spending over the foreseeable future, the Canadian Forces will have to identify and choose very carefully which capabilities and technologies are required given its limited budgetary envelope.

THE REVOLUTION IN MILITARY AFFAIRS

According to Sloan, "one of the most important trends that will affect Canada's security and defence policy over the next two decades is the Revolution in Military Affairs (RMA)."[20] Although the importance of the RMA to Canada and its NATO allies is still the subject of intense debate, it is clear that the RMA will play a significant role in defining future CF combat capabilities and shaping its organizational structure and fighting doctrine. To better understand the nature and the likely impact of this American-led RMA, it is necessary to examine its origin and current manifestation in the US military.

[19] 27% cut to departmental personnel. In Canada. Department of National Defence. "Defence Planning Guidance 2000." (Ottawa: DND Canada, 1999). Art 104.

The origin of the RMA

By the late sixties, NATO countries had clearly realized that the nuclear stalemate between the two superpowers and the theory of mass destruction which had formed the basis of Western military doctrine had led the world to an inescapable fate. The West had to find a new way to defend itself against a Soviet attack on the European front without using nuclear weapons. Inspired by the Yom Kippur campaign of 1973, American military strategists devised a new theory of warfare based on the concept of 'deep battle' which called for the deepening of the battlefield and the attack of the rear echelons of an invading army using high tech weapons with longer ranges. New organizational structures based on joint operations were developed and technical requirements for new weapons and technologies were drafted. Among these were the requirements for the M-1 Abrams tank, the Apache helicopter and the JSTARS ground surveillance aircraft. After years of concept development and research, a new doctrinal concept for the US army was published in March 1981: *The Air Land battle*.[21] Ten years later the doctrinal, organizational and technical innovations embodied in the Air Land battle concept were demonstrated with success during the Persian Gulf War.

While the doctrinal and organizational changes proposed by the Air Land battle concept were very important, it is the development and exploitation of advanced technologies that have made its implementation possible. Over the past forty years, rapid advances in many fields of technology have transformed and arguably revolutionized the way civilian and military institutions conduct their business. The invention of the

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[20] Sloan, Elinor C. "Canada and the Revolution in Military Affairs", Directorate of Strategic Analysis Policy Planning Division, Report No 2000/14, Jun 2000. ix.

[21] For a detailed discussion on the evolution of the concepts of active defence, deep battle and the AirLand battle see Toffler, Alvin and Heidi. "War and Anti-wars – Survival at the dawn of the 21st Century". Little, Brown and Company, Boston. 1993. Chapter 7.

transistor in 1947 paved the way for solid-state integrated circuits followed by modern electronic devices and telecommunication. By the late fifties, the first fully transistorized digital computer had been developed and a few years later, transistor technology made possible the development of the first communication satellite. The commercialization of inexpensive microchips by the mid-1970s led to significant developments in many technologically-related fields such as computer and networking, telecommunication and sensor technology. By the mid-eighties, these technologies had given birth to satellite communication and navigation, remote sensing from space, high-speed command and control networks, airborne intelligence and surveillance platforms and precision weapons. These new technologies have been instrumental to the transformation of the US military doctrine: their exploitation has been the key to the success of the coalition during the Gulf War.

Following the end of the Gulf War, several US commissions and research groups[22] were tasked to examine the impact of ongoing technological advances on future warfare concepts. Their research led to the identification of key operational concepts that were considered dominant approaches in future warfare.[23] These key operational

[22] Example of commissions and research groups involved in RMA research are the Commission on Integrated Long-Term Strategy and the Centre for Strategic and International Studies. In Watts, Barry D. "What is the Revolution in Military Affairs?" Northrop Grumman Analysis Center. Apr 1995.

[23] In addition to examining the ongoing impact of technology, some research groups attempted to define and characterized the transformation which was taking place. Some researchers proposed that the US military was undergoing a Military Technological Revolution (MTR) while others, including Andrew W. Marshall Director of Net Assessment in the Pentagon, indicated that the transformation was a Revolution in Military Affairs (RMA). The term Military Technological Revolution was first employed by Soviet military theorists in the early 1970's to describe periods of fundamental military change in the 21st century. "The first one was driven by the emergence of aircraft, motor vehicle and chemical warfare during World War I and the second driven by the development of nuclear weapons, missiles and computers in World War II. According to the Soviets, the next MTR would involve microelectronics, sensors, precision-guidance, automated control systems and directed energy." In Galdi, Theodore W. "Revolution in Military Affairs? Competing Concepts, Organizational Responses, Outstanding Issues. US Foreign Affairs and National Defence Division. Dec 1995. http://www.fas.org/man/crs/95-1170.htm. The March 1993 report produced by the Centre for Strategic and International Studies defined MTR as "a fundamental advance in technology, doctrine or organization that renders existing methods of conducting obsolete." Watts. 4. According to Marshall, a Revolution in Military Affairs is "a major change in the nature of warfare brought

concepts became the foundation of the new US military vision for the 21st century - *Joint Vision (JV) 2010* – published in July 1996.[24] According to JV 2010, the four key operational concepts that will allow the US military to achieve full spectrum dominance[25] are:

> Dominant manoeuvre – "the ability of joint forces to gain positional advantage with decisive speed and overwhelming operational tempo in the achievement of assigned military tasks;"[26]
>
> Precision engagement – "the ability of joint forces to locate, surveil, discern and track objectives or targets; select, organize and use the correct systems; generate desired effects; assess results; and reengage with decisive speed and overwhelming operational tempo as required, throughout the full range of military operations;"[27]
>
> Focused logistics – "the ability to provide the joint force the right personnel, equipment and supplies in the right place, at the right time, and in the right quantity …;"[28] and
>
> Full dimensional protection – "the ability of the joint force to protect its personnel and other assets required to decisively execute assigned tasks."[29]

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about by the innovative application of new technologies which, combined with dramatic changes in military doctrine and operational and organizational concepts fundamentally alters the character and conduct of military operations." Sloan. 1.

[24] JV 2010 was reviewed and re-published in Jul 97 as JV 2020.

[25] Full spectrum dominance is defined as the ability of US forces, operating unilaterally or in combination with multinational and interagency partners, to defeat any adversary and control any situation across the full range of military operations. In United States. Department of Defense. "Joint Vision 2020" Washington D.C. Jul 1997. 6.

[26] JV 2020. 20.

[27] JV 2020. 22.

[28] JV 2020. 24.

[29] JV 2020 further defines full dimensional protection by stating that it is achieved through the tailored selection and application of multilayered active and passive measures, within the domains of air, land, sea, space and information across the range of military operations. In JV 2020. 26.

JV 2010 also identifies the overarching concept of '*information superiority*' as the key enabler to the four fundamental operational concepts. Information superiority is defined as "the capability to collect, process and disseminate an uninterrupted flow of information while exploiting or denying an adversary's ability to do the same."[30]

The implementation of JV 2010 in the US military will necessitate significant and far-reaching doctrinal, organizational and technical reforms which will transform the way they will conduct military operations in the future. This is the essence of the present American 'Revolution in Military Affairs'.

Importance of the RMA for Canada

Given the undeniable and growing presence of the RMA[31] in Western military affairs, Canada (and its allies) must assess its impact and determine its potential and value. It can be argued that the RMA is very important to Canada and the Canadian Forces for a number of reasons.

From a global or societal point of view, the warfare concept proposed by the RMA is a more 'humane' way of conducting war. As discussed by Freedman, the strategic theories embodied in the RMA have returned war from "a process of destruction to a fight."[32] Furthermore, this new warfare concept is more in line with the expectations of today's Western societies. According to Branch-Evans, "the RMA offers a way of war which is particularly well matched to the evolving model of morality that appeals to the

[30] JV 2020. 8.
[31] According to Sloan, "while the speed at which the revolution in military affairs is being pursued is uncertain, that it will be pursued is not. In Sloan, Elinor. "The United States and the Revolution in Military Affairs." Directorate of Strategic Analysis Policy Group, Report No 9801, Feb 1998. vii.

political and public perceptions of the liberal democracies of the US and Western Europe."[33] Finally, the RMA warfare concept proposes to minimize casualties and collateral damage: two critical issues that have become unacceptable to Western societies.[34]

From a purely military perspective, the RMA is very appealing due to its proven performance during the Gulf War. During this operation, the US-led coalition was able to achieve military success by employing the doctrine and much of the technologies comprising the RMA. Moreover, the technological superiority proposed by the RMA agrees with fundamental principles of military theory founded on the experiences of the First and Second World War.[35] Of significance also is the fact that the RMA claims combat effectiveness for small size military forces. Given the reduction in military personnel in Western military organizations over the past ten years, this feature becomes very important.

Finally, from a national and Canadian military perspective, some aspects of the RMA are fundamentally important to national security and military operations. Canada's defence policy is based on cooperation with US military forces in the defence of North America as well as during UN-sanctioned coalition operations. The ability of the Canadian Forces to inter-operate with US forces is an absolute requirement. This reality is echoed by Mitchell: "should we [Canada] wish to continue to participate in

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[32] Freedman, Lawrence. "The Revolution in Strategic Affairs." International Institute for Strategic Studies. Adelphi Paper 318. 1998. 15.
[33] Branch-Evans, Simon. "Evolution of Warfare: How will the RMA make a Difference?" in Managing the Revolution in Military Affairs edited by Matthews, Ron and Treddenick, John. Palgrave Publisher Limited. 2001. 51.
[34] Freedman. 15, 16.
[35] The significant advantages offered by superior technologies have been clearly demonstrated on many occasions during the Second World War. The exploitation of direction finding equipment and radar by the Allies are good examples.

international coalition operations as we have over Iraq and Yugoslavia in the past decade, interoperability will require that we adopt portions of the RMA simply to allow our forces to contribute."[36] To be effective and fulfill its defence mandate, the Canadian Forces must be equipped with technologies compatible with the US military and must also use common combat doctrine.

Over the next twenty-five years, the defence missions assigned to the Canadian Forces will remain the defence of Canada and North America with its US ally and participation in UN and NATO operations. The ability of the Canadian Forces to accomplish these defence missions will depend to a large extent on its ability to acquire, integrate and exploit RMA technologies and concepts. However, as will be discussed in the next section, RMA technologies are very expensive and may not be affordable by many NATO nations including Canada.

[36] Mitchell, Paul. "The Revolution in Military Affairs and the Canadian Air Force". In Air Power at the Turn of the Millennium edited by Rudd, Hanson, Beauregard, Canadian Institute of Strategic Studies. 1999. 42.

III. RMA: A MATTER OF CHOICE

Despite demonstrated benefits and proven success, the RMA has not yet been embraced unanimously by all coalition partners. One of the major issues to be addressed is the question of affordability. Struggling with smaller defence budgets, aging equipment and increasing personnel costs, Canada and its NATO allies are faced with difficult choices which will have a profound impact on the future of the Western Alliance. Reflecting on the importance and impact of the RMA, Defence Minister Art Eggleton indicated that: "Defence will have to choose wisely when selecting RMA technologies and capabilities. The future effectiveness of the Canadian Forces, and its allies to operate in a coalition of like-minded nations, will depend on these choices."[37]

Over the past few years, the RMA debate has started to focus more on the question of cost. A number of critics have expressed concern that the inability of several smaller countries to purchase RMA technologies would lead to the emergence of a two-tier alliance.[38] Others have argued that simple coordination of computer and communication system purchases would ensure operational effectiveness of the alliance in the future.[39] One of the options proposed for middle-power countries like Canada to address the problem of affordability is the concept of 'niche capability'.

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[37] Canada. Department of National Defence. "Plan and Priorities 2001-2002." (Ottawa: DND Canada, 2001) 13.
[38] Freedman. 70.
[39] O'Hanlon, Michael. "Military Innovation and Allied Operations." National Security Studies Quarterly. Spring 1999. 77.

NICHE CABABILITY

Given the high cost of RMA technologies and the great difficulty experienced by many Western countries in generating funds for capital acquisitions[40], a new approach is required before the technological gap between the US and its allies become unmanageable and the effectiveness of the coalition is seriously weakened. In his essay on NATO and the RMA, Read proposed an alternative to the high cost of the RMA based on niche capability.[41] He argued that the future of NATO lies in its ability to align the capabilities of smaller alliance members in either complementary or supplementary roles to the more technologically advanced American forces, thereby exploiting the idea of role specialization. Read goes on to propose that specialization could be determined by each country based on existing and planned future capabilities as well as on national military expertise, requirements and interest. Considering the fiscal realities of Western defence budgets and the necessity to formulate a harmonized plan acceptable to all members, it could be argued that this approach is the only option available to the Alliance. The question then really becomes a matter of identifying and selecting an RMA niche meeting the needs and capabilities of each coalition partner.

Identifying the RMA niches

A close examination of the operational concepts embodied in JV 2010 reveals four technologies or 'capability areas' that are key to the implementation of the joint vision. These are:

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[40] Treddenick, John M. "Financing the RMA." In Managing the Revolution in Military Affairs edited by Matthews, Ron and Treddenick, John. Palgrave Publishers Limited. 2001. 99-108.
[41] Read, David W. "The Revolution in Military Affairs: NATO's Need for a Niche Capability Strategy." Canadian Military Journal. Autumn 2000. 22.

Precision weapons;[42]

Strategic/tactical lift;[43]

Command, Control, Communication, Computers and Intelligence (C^4I);[44] and

Intelligence[45], Surveillance[46] and Reconnaissance[47] (ISR).[48]

The first capability area, precision weapons, is the key to achieving precision engagement and full dimensional protection. It includes advanced air-to-air missiles and air-to-ground precision guided munitions (PGM) as well as stand-off missiles. The second capability area, strategic and tactical lift capabilities, is necessary to move the military forces to and within the theatre of operation. These lift capabilities are required to achieve dominant manoeuvre and focused logistics. The third capability area, C^4I, represents the backbone information and intelligence system of the military force and is a prerequisite to achieving precision engagement, full dimensional protection, dominant manoeuvre and focused logistics. Finally ISR, which comprises all the sensors and data collection mechanisms employed in the theatre of operation, is required by an RMA-

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[42] JV 2010 and "Looking in the Mirror: Where are our Asymmetric Vulnerabilities?" McNair Paper 62. Nov 2000. 2.
http://www.ndu.edu/inss/macnair/mcnair62/CH03.html

[43] JV 2010 and "Looking in the Mirror: Where are our Asymmetric Vulnerabilities?" 2.

[44] JV 2010 and "Looking in the Mirror: Where are our Asymmetric Vulnerabilities?" 2.

[45] Intelligence is defined as the product resulting from the collection, processing integration, analysis, evaluation, and interpretation of available information concerning foreign countries or areas; it is the information and knowledge about an adversary obtained through observation, investigation, analysis, or understanding. In United States. Department of Defence. "Intelligence, Surveillance and Reconnaissance Operations." Air Force Doctrine Document 2-5.2. 21 Apr 1999. 1.

[46] Surveillance is defined as the systematic observation of aerospace, surface or subsurface areas, places, persons, or things, by visual, aural, electronic, photographic or other means. In (US) Air Force Doctrine Document 2-5.2. 2.

[47] Reconnaissance is defined as a mission undertaken to obtain, by visual observation or other detection methods, information about the activities and resources of an enemy or potential enemy, or to secure data concerning the meteorological, hydrographic, or geographic characteristics of a particular area. In US Air Force Doctrine Document 2-5.2. 2.

[48] Refer to JV 2010 and "Looking in the Mirror: Where are our Asymmetric Vulnerabilities?" 2.

equipped military to achieve precision engagement, full dimensional protection and dominant manoeuvre.

In the conceptual vision of JV 2010, these four capability areas are integrated together to form a closely coupled 'system of systems' that will allow the military force to operate in a very effective manner. Advanced ISR sensors will collect data in the theatre of operation and transmit this data rapidly to C^4I systems. Using the advanced processing and correlation capabilities of modern C^4I systems, the data will be analyzed and converted into usable information that can then be disseminated to dispersed air, sea and land units across the battle area. The C^4I systems will also give theatre commanders access to a network of precision weapons and the ability to rapidly direct precision strikes against detected hostile targets. Finally, strategic lift capability will ensure that personnel, equipment and supply are available where and when required and tactical lift capability will guarantee greater force mobility to outmanoeuvre the enemy.

These four capability areas are the essence of the technological aspect of the RMA and constitute areas of specialization or 'niches' open to coalition members. As discussed by Read, the intent is not to take over full responsibility for a given area but to contribute to coalition efforts by supplementing already existing capabilities or by complementing coalition capabilities with a unique capability.

Selecting the RMA niche

As stated previously, the selection of an appropriate RMA niche should be based on national selection criteria derived from national defence obligations, existing and

planned future capabilities, military expertise and national interest. In the case of Canada, five selection criteria have been identified:

1. Contribute to defence missions – i.e. sovereignty, defence of North America and contribution to international peace and security;

2. Usefulness/value across the spectrum of military conflict;

3. Existing industrial base and Research and Development (R&D) in Canada;

4. Supportable by Canadian public; and

5. Return on investment.

Although it could be argued that other criteria would also have to be considered, this simple yet fundamental set of criteria reflects well political, economic, military and social imperatives that Canada and the Canadian public would consider important. It should be noted that *affordability* was not included as a criteria because it is assumed that the Canadian Government would be willing to invest in the development of a niche capability.

The first RMA niche to be examined – precision weapons – can be eliminated rapidly without much argumentation since it clearly fails to meet two of the criteria. Although Canada will continue to purchase and use a few types of precision weapons for its CF 18 fighter aircraft, the idea of becoming a leader in the development and sale of 'offensive weapons' would go against the Canadian persona as a 'peace loving' nation and would therefore be totally unacceptable to the Canadian public. Furthermore,

Canada does not and is not likely to have an industrial base or a significant R&D capability in this field.

The second niche, strategic/tactical lift, must also be eliminated based on return on investment and, to a certain extent, lack of relevant industrial base. Although the acquisition of strategic airlift capabilities would contribute to the performance of the defence missions and would be useful in all operations across the spectrum of military conflicts, it does not constitute a good return on investment. Since heavy strategic airlift are only used when conducting large military operations involving movement of heavy military equipment, they would remain largely underutilized. It is for this very reason that the Air Force is currently examining leasing options in collaboration with other NATO nations.[49] A second reason for rejecting this niche is that Canada does not have a relevant industrial base. Although Canada has a substantial aerospace industry, it is primarily focused on small to medium size commuter planes and not on heavy lift aircraft. Given the leading advantage and significant market share already taken up by American and French aerospace companies, an investment in this area would be highly risky.

It can be argued that the third niche, C^4I, is not a good niche capability because most Western countries are already investing significantly in information and telecommunication technologies[50] not only for military purposes but also for commercial reasons. For the past decade, most industrialized countries have been developing information infrastructures and modern telecommunication networks to meet the growing

[49] Presentation made to the Canadian Forces College by BGen Watt, A3 Operations 1 Canadian Air Division Winnipeg, 31 Jan 2002.
[50] According to Sloan, "Canada is also investing in advanced command, control, communications, computers and intelligence processing (C4I) capabilities." See Sloan, Elinor C. "Canada and the Revolution

demand of the global economy. These commercial technical developments have fueled parallel developments in military technologies and led military organizations to embrace computers, networking and wireless communication as the backbone of their command and control infrastructure. An investment in C^4I as a niche capability would have limited value for NATO partners since most countries already have or will soon have their own capability. The real challenge in this particular capability area is not one of possession but of interoperability between systems.

The last capability area, ISR, clearly meets all the niche selection criteria. The development and implementation of a Canadian ISR capability would not only greatly contribute to the fulfillment of the defence missions as will be discussed later on in this essay, but it would also beneficially supplement existing coalition capabilities. From an economic perspective, the development of an ISR capability in Canada would agree with existing industrial base and R&D capability[51] and the exploitation of such a capability would undoubtedly meet acceptance and expectations from the Canadian public. Finally, an investment in ISR technology would constitute a very good return on investment since it would provide Canada with a capability not only useful during deployed military operations, but also year round to monitor and ascertain the sovereignty of the Canadian territory and the security of the North American continent.

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in Military Affairs." Directorate of Strategic Analysis Policy Planning Division, Policy Group. Project Report No 2000/14. Jun 2000. 8.

[51] Canada possesses a good industrial base and R&D capability in many fields related to ISR technologies. The development of the Canadian RADARSATs (1 and 2) and the many R&D projects in radar and electro-optical technologies carried out by the Canadian Defence Research establishments - such as the Spotlight Synthetic Aperture Radar (SAR) developed for the CP140 Maritime Patrol aircraft - have been instrumental in making Canada a leader in the field of remote sensing. A complete description of RADARSAT R&D and current Defence Research and Development Canada areas of research are found at: http://www.space.gc.ca/csa_sectors/earth_environment/radarsat/default.asp; http://www.drdc-rddc.dnd.ca/menu_e.html (Annual Report 2000-2001).

ISR: AN ESSENTIAL POLITICAL AND MILITARY CAPABILITY

The importance attributed to ISR in JV 2010 as an essential operational capability underscores its immense and critical value in military operations. As stated in US Air Force (USAF) doctrine, "[T]he information derived from surveillance and reconnaissance, converted into intelligence by fusion and analysis, is used to formulate strategy, policy and military plans; to develop and conduct campaign; and to carry out military operations."[52] Intelligence information provides government officials the awareness required to make informed decisions and allows military planners and strategists to develop sound and comprehensive plans. While the possession of intelligence information is vital to political and military decisions, its accuracy and completeness is also of critical importance. Incomplete, inaccurate or even lack of intelligence information may result in poor or incorrect decisions that could have a serious impact on military operations or cause embarrassment to Canada and the Canadian government. Decisions based on second-hand sources obtained from military allies are even more hazardous militarily and politically because if the information is incomplete or biased, the decision maker may unknowingly be led into making an erroneous decision and will have no way of confirming the credibility of the information presented. While poor decisions based on first-hand information collected by Canadian sources may never be unavoidable due to the human nature of the process and the impossibility of obtaining complete information, poor decisions based on somebody else's information is irresponsible and simply inexcusable.

The development of an ISR capability for Canada is an area which has never been given much attention. According to Sloan, "… Canada … is almost entirely dependent

[52] US Air Force Doctrine Document 2-5.2. 2.

on the United States for its intelligence collecting, surveillance and reconnaissance information."[53] Reliance on the UN for intelligence information prior to deployment for a peace mission is not and has never been an option. As indicated by Rehbein, the UN has no formal intelligence gathering capability and must rely on member states to obtain such information.[54] Although reliance on the US for intelligence information may have been sufficient and acceptable during the Cold War period given common defence objectives and similar foreign policy goals, the new political and strategic environment which has characterized the past decade constitutes sufficient justification for re-evaluating the need for a Canadian ISR capability. As Canada enters the 21st century, it must be able to pursue its own foreign policies and defence objectives and must be able to make its own independent decisions based on independently collected and analyzed intelligence information. Continued reliance on the US for intelligence information will inevitably lead to poor or disastrous decisions and will erode Canadian character and identity. Furthermore, Canada's ability to rely on the US for intelligence information may soon be coming to an end. As reported by Godefroy, "[T]he US has in general pared down Canadian access to American data over the last two decades, and US security interests will undoubtedly continue to deny Canada access to some of its lead systems and certain intelligence, surveillance and reconnaissance data."[55] The way forward is clear. Without an independent ISR capability, Canada will never be the complete master of its policies and decisions.

[53] Sloan. 10.
[54] Rehbein, Robert E. "Informing the Blue Helmets: The United States, UN Peacekeeping Operations, and the role of Intelligence." Centre for International Relations, Martello Papers. 1996. 2, 23.
[55] Godefroy, Andrew B. "Is the Sky Falling? Canada's Defence Space Programme at the Crossroads." Canadian Military Journal. Vol 1 No. 2 Summer 2000. 14.

IV. ISR DEFINED

The identification of an adequate ISR capability for Canada is a challenging task due to the broad scope of the Canadian defence missions and the diversity of military operations in which Canada may be called upon to participate in as a member of a multinational coalition. A Canadian ISR capability must be able to fulfill domestic surveillance requirements over the Canadian territory but must also be able to provide a much needed support to military operations across the spectrum of possible military conflicts ranging from peacekeeping missions to war. Moreover, if a Canadian ISR capability has to be defined in the context of an RMA niche, it must take into consideration the operational architecture emerging from the US Joint Vision 2010. To better understand the requirements to be met by a Canadian ISR capability, it is first necessary to examine the concepts of 'battlespace awareness' and of the 'systemystem

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> "Know the enemy and know yourself; in a hundred battles you will never be in peril. When you are ignorant of the enemy but know yourself, your chances of winning or losing are equal. If ignorant both of your enemy and of yourself, you are certain in every battle to be in peril."[56]

In war, decisions about whether to launch an offensive or remain on the defensive are based on information about the state of one's own forces, the state of the enemy's forces, the terrain, the climate and so on.[57] "To obtain information in the past, commanders have relied on books, maps, scouts, travelers, deserters, prisoners, diplomats and spies."[58] For centuries, these rudimentary methods of collecting information were the only means available to the military commander to gather information about the enemy and they have defined, to a large extent, the limit of his ability to visualize and understand the battlefield. With the advent of technology appearing in the late nineteenth century, the ability of the military commander to collect information and to see the battlefield beyond the visual range has allowed him to achieve a much greater level of understanding of the battlefield.

> "During World War I, primitive reconnaissance aircraft and observation balloons were used to locate enemy troops and direct artillery fire. World War II brought a massive expansion of technology used to locate and pinpoint the enemy, including radar, radio direction-finding equipment, and sonar used to locate submarines. The Cold War saw the technology of surveillance taken high above the earth with the top secret U-2 spy plane, and later a galaxy of unmanned satellites that used photography, electronic eavesdropping, light-sensitive devices, and radar to study the earth and its battlefields." … " General Schwarzkopf, the commander in chief of allied forces in Operation Desert Storm in 1991, was able to 'see' what was occurring in an area nearly 250,000 square miles with dramatically greater fidelity

[56] Griffith. 84.
[57] Van Creveld, M. "Command in War." (Cambridge, Massachusetts: Harvard University Press, 1985). 18.
[58] Fairbanks, Walter P. "Information Superiority: What is it? How to Achieve it?" Center for Information Policy Research. Harvard University. Jun 1999. 1.

and accuracy than any other previous military commander in any previous conflicts."[59]

Today's modern technology has given the military commander the ability to see and understand the entire battlefield – air, land and sea - or 'battlespace'[60] as it is now currently referred to, by day and night, in most weather conditions and at all times. In future military conflicts, the commander will have immediate access to a live, three-dimensional representation of the entire battlespace displayed on a computer screen, an image generated by a network of sensors including satellites, unmanned aerial vehicles, surveillance aircraft and soldiers on the ground. He will know the precise location and movement of enemy forces at all times as well as the location and status of his own forces. His decision to manoeuvre his troops, engage the enemy or remain on the defensive will be based on facts, not uncertainties.

The anticipated achievement of this unprecedented level of understanding of the battlespace has led to the concept of *battlespace awareness*, defined by US Navy Admiral Williams Owens as "a senior's commander's overall comprehension of the enemy, his own forces, the battlefield terrain, and any other factors that will influence the course of battle…"[61] Ultimately, the goal of the US military is to achieve 'Dominant Battlespace Knowledge', a state of information dominance which may be defined as "superiority in the generation, manipulation, and use of information sufficient to afford its possessors military dominance."[62]

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[59] Owens, Bill. "Lifting the Fog of War." Farrar, Strauss and Giroux. New York. 2000. 12, 13.
[60] With the advent of space technology and its use in military operations, the traditional view of the three dimensional battlefield – air, land and sea – has now been redefined as a much larger operational area – the *battlespace*. Some authors argue that the battlespace also includes cyberspace. In Branch-Evans, Simon. 53 End notes.
[61] Owens. 15.
[62] Libicky, Martin C. "Information Dominance." Institute for National Strategic Studies. No. 132. Nov 1997. http://www.ndu.edu/inss/strforum/forum132.html

The 'System of Systems'

Up until 1990, the US military had not had the real opportunity to put into practice the concepts of the AirLand battle or test on a large scale the effectiveness of many new military technologies developed over the previous decades. The 1991 military victory in the Gulf War not only confirmed the effectiveness of doctrinal changes and technologies but more importantly, demonstrated that significant improvement in combat effectiveness could be achieved by the seamless integration of sensor, communication and weapon systems. The development and fielding of this 'system of systems'[63] has become the major drive of the current American RMA.

As discussed by Owens,[64] the *system of systems* is comprised of three main components: the intelligence collection system, the information analysis and distribution system and, the precision engagement system.[65] The intelligence collection system can be pictured as the eyes and ears of the military force in the battlespace. It includes the platforms and sensors associated with intelligence gathering, surveillance and reconnaissance (ISR) as well as the reporting technologies required to forward the information from the sensing platform to a command centre for analysis or to a strike aircraft for immediate engagement. The information analysis and distribution system, also referred to as the command, control, communications, computers and intelligence (C^4I) component of the system of systems, is the central nervous system of the military force. Composed primarily of networks of computers and communication devices, its

[63] This expression has been popularized by US Admiral William Owens who served as vice chairman of the US Joint Chiefs of Staff in the mid-1990s.
[64] Owens, William A. "The Emerging of the System of Systems." Proceedings. May 1995. 36. Note that the System of Systems is also discussed at length in Owen W. "Lifting the Fog of War" 15, 16, 99-101.
[65] In its network-centric warfare concept, the US Navy has identified these three systems as the sensor grid, the information grid and the engagement grid. In Cebrowski, Arthur K. and Garstka, John J. "Network-Centric Warfare: Its Origin and Future." US Naval Institute Proceedings . Jan 1998.

purpose is to gather, analyze and correlate the information received from the intelligence collection system and to distribute the derived intelligence to commanders and decision makers at all levels across the battlespace. The third system – the precision engagement system – is the strike capability of the military force. It includes the vast array of precision weapons available today such as precision-guided gravity bombs, laser guided artillery shells and sea or air-launched cruise missiles that use satellite navigation information to guide their trajectory to the target. Once fully integrated into a single, seamless entity, it is expected that the system of systems will provide the military commander the ability to detect, identify and engage any hostile target in real time or near real time, in most weather condition, by day or night.

Technically speaking, the successful development and seamless integration of the ISR and C^4I components of the system of systems are the key to the achievement of total battlespace awareness and Dominant Battlespace Knowledge. However, from an operational perspective, the achievement of battlespace awareness also requires the judicious selection and employment of the many ISR assets available to the military commander. This selection requires a thorough understanding of the capabilities and limitations of each ISR asset.

ISR ASSETS OF THE SYSTEM OF SYSTEMS

The ISR Discipline

Before discussing the roles, capabilities and limitations of ISR assets, it is first necessary to review the terminology and specialties making up the ISR discipline. 'ISR'

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http://www.usni.org/Proceedings/Articles98/PROcebrowski.htm.

– Intelligence, Surveillance and Reconnaissance – is the acronym used by the military to describe the complete intelligence gathering capability available to the commander in support of military operations. More specifically, ISR can be defined as the "integrated capabilities to collect, process, exploit and disseminate accurate and timely information that provides the battlespace awareness necessary to successfully plan and conduct operations."[66] The terms Intelligence, Surveillance and Reconnaissance also have very specific meaning:

> Intelligence is "the product resulting from the collection, processing, integration and analysis, evaluation, and interpretation of available information"[67] obtained through surveillance and reconnaissance. According to US doctrine, "[S]urveillance and reconnaissance are the primary means of collecting information used to produce intelligence."[68]
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> Surveillance is defined as "the systematic observation of aerospace, surface or subsurface areas, places, persons, or things, by visual, aural, electronic, photographic or other means."[69]
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> Reconnaissance is defined as "a mission undertaken to obtain, by visual observation or other detection methods, information about the activities and resources of an enemy or potential enemy, or to secure data concerning the meteorological, hydrographic, or geographic characteristics of a particular area."[70]

Although observations and information collected by ground troops play an important part in the construction of the total intelligence picture, the advantage of speed

[66] US Air Force Doctrine Document 2-5.2. 1.
[67] US Air Force Doctrine Document 2-5.2. 1.
[68] United States. Department of Defence. "Operations." FM 3-0. (Washington D.C.: Department of the Army, Jun 2001). 11-8.
[69] US Air Force Doctrine Document 2-5.2. 2.
[70] US Air Force Doctrine Document 2-5.2. 2.

and elevation above the ground have conferred airborne platforms a leading role in intelligence gathering. This category of air operations - aerospace surveillance and reconnaissance – involves the gathering of information using photographic, radar, infrared, electronic, acoustic and visual methods. These collection methods are broken down into a number of intelligence categories. The three main intelligence categories or capabilities are Airborne Early Warning and Control (AEW & C), Imagery Intelligence (IMINT)[71] and Signals Intelligence (SIGINT).[72]

Aerospace surveillance and reconnaissance in the modern battlefield are performed primarily by three types of airborne ISR platforms: surveillance satellites, unmanned aerial vehicles (UAVs) and manned aircraft. These systems have different but complementary capabilities.

Surveillance Satellites

The exploitation of space for military and commercial purposes has been an area of growing interest and rapid development since the early sixties. During the first decade of space exploration, all the satellites were built and launched by the US and the former Soviet Union. Today, most industrialized countries possess at least one or more communication satellites and many are investigating or pursuing the development of meteorological, navigation, remote sensing or space research satellites.

[71] Imagery Intelligence (IMINT) is defined as "intelligence derived from the exploitation of collection by visual photography, infrared sensors, lasers, electro-optics, and radar sensors such as synthetic aperture radar wherein images of objects are reproduced optically or electronically on film, electronic display devices, or other media." In United States. Department of Defence. "Dictionary of Military and Associated Terms." Joint Publication 1-02. Washington D.C.. Apr 2001. 203.

[72] Signals Intelligence (SIGINT) is defined as "a category of intelligence comprising either individually or in combination all communications intelligence (COMINT) and electronic intelligence (ELINT). SIGINT uses intercepted electromagnetic emissions to provide information on the capabilities, intentions,

In military applications, satellites are used primarily in surveillance and reconnaissance roles. Military surveillance satellites can be broken down into three main categories: early warning, imagery and electronic surveillance satellites. Early warning satellites are designed primarily to detect the launch of Intercontinental Ballistic Missiles (ICBMs). These satellites use infrared sensors to detect hot exhaust plume emanating from the missiles.[73] Imagery satellites[74] provide detailed images of areas of interest on the surface of the earth. They are fitted with one or more sensors operating in the visual, ultra violet or infrared band of the electromagnetic spectrum as well as in the radar frequency band (i.e. imaging radars). The third category of satellite is the electronic surveillance satellite[75] which is designed to pick up and record radar and radio transmissions originating from the earth's surface.

The civilian exploitation of orbiting satellites also goes back to the early sixties with the launch of the first communication satellite, *Echo 1*, in 1960 followed by the first remote sensing satellite, *TIROS 1*, also in 1960. As the potential of remote sensing technology for many civilian applications like environmental monitoring and cartography became better understood, a significant demand for higher resolution imagery led to the

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formations, and locations of adversary forces." In United States. Department of Defence. "Dictionary of Military and Associated Terms." Joint Publication 1-02. Washington D.C.. Apr 2001. 398.

[73] The American "Defence Support Program" (DSP) is the current operational satellite system designed for this purpose. In Dutton, Lyn *et al*. "Military Space." Brassey's (UK). London. 1990. 106.

[74] Imagery satellites can be further broken down into two subcategories based on the height of their orbit around the earth. Area surveillance satellites are those that are positioned in high geostationary orbits above the earth (above 20,000 miles). From this relatively high position above the earth, they are able to instantly surveil large surface areas but the increased distance from the surface of the earth effectively reduces the resolution of their sensor systems. Low earth orbit satellites, also referred to as high resolution or 'close look' satellites, are those satellites that are orbiting the earth in much lower orbits, normally between 100 and 300 miles. Due to their relatively closer distance from the surface of the earth, they are able to provide much higher resolution imagery but the area covered is a narrow swath of the earth's surface which can only be overflown at regular but distant time intervals (i.e. two or more days depending on the satellite trajectory).

[75] Most communication surveillance (COMINT) and electronic surveillance (ELINT) satellites are flown in high geostationary orbits. In Oxlee, G.J. "Aerospace Reconnaissance" Brassey's. London. 1997. 54.

development and launch of new civilian satellites. Two good examples of satellites employed extensively in civilian applications are the US LANDSAT series (LANDSAT 1 launched in 1972) and the French Système Photographique pour l'Observation de la Terre (SPOT), launched in February 1986. During the Gulf War, the US military used SPOT imagery for mission planning purposes. [76] Since then, the employment of civilian satellite imagery for military purposes has become the subject of much interest in military circles around the world.

Surveillance satellites, and more particularly imagery satellites, offer many advantages over other types of ISR assets. First, they provide world-wide coverage and therefore the ability to surveil any areas of interest on the earth. They can also rapidly search a large surface area and detect medium to large size objects such as a ship or a building. Smaller objects such as vehicles can also be detected by low earth orbit satellites as they overfly the search area but a time delay necessary for the satellite to move into position may be encountered. Imagery satellites are also ideally suited for periodic revisit of areas of interest where the observation of changes or trends are important. Finally, satellites are relatively immune from adversary action when compared to other airborne ISR assets and they are the least intrusive means of collecting intelligence data.

Satellites also have a number of disadvantages or weaknesses. Firstly, their schedule is predictable, therefore making them vulnerable to denial (i.e. hiding objects of interest during satellite passes) and deception. Secondly, due to their long revisit time, they are not well suited for the detection of rapidly changing events or situations. A third disadvantage or weakness of imaging satellite is their susceptibility to weather conditions

[76] Oxlee. 61.

such as clouds, rain and fog: however, in all fairness it must be stated that this factor also affects other ISR assets. A fourth weakness of satellites and satellite sensors are their inability to search the air for airborne targets or the sea for submerged targets. Currently existing satellites are also only able to downlink information to dedicated ground stations and not yet directly to strike aircraft (which would, in effect, reduce the sensor to shooter time delay). Finally, satellites are very expensive to develop and operate.

Unmanned Aerial Vehicles

Unmanned Aerial Vehicles[77] (UAVs) have been in service with many military forces around the world since the Second World War and have gained immense popularity in the past two decades.[78] They can be loosely regrouped into three main categories: low-endurance tactical, medium-altitude endurance (MAE) and high-altitude endurance (HAE) UAVs. The tactical UAVs have been in service with military ground forces for several decades. These short-range, lightweight remotely piloted vehicles are used extensively for tactical reconnaissance and area surveillance. The American *Pioneer*, the British *Hunter* and the Israeli *Heron* are good examples of this category. Medium-altitude endurance UAVs have started to appear in the 1980s but it is not until

[77] Unmanned Aerial Vehicles (UAV) are defined as "powered, aerial vehicle that does not carry a human operator, uses aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or non-lethal payload. Ballistic or semi-ballistic vehicles, cruise missiles and artillery projectiles are not considered unmanned aerial vehicles." US Joint Publication 1-02. 458.

[78] Early British and American experiments with remotely piloted vehicles (RPVs) employed in intelligence gathering and reconnaissance roles demonstrated the viability of the concept and brought to light the many advantages of small, unmanned vehicles in the combat environment. Although successfully employed in reconnaissance missions by the US military during the Vietnam War, it is not until the 1982 Israeli air campaign in the Bekaa Valley that RPVs became the focus of renewed interest in many military circles. During the following decade, the introduction of state-of-the-art computer and sensor technologies in RPVs led to the development of a new and more capable platform, the UAV. These new vehicles were first put to the test during the Gulf War where they were used for gunfire support, day and night surveillance, target acquisition, route and area reconnaissance and battle damage assessment. Based on their excellent performance during the Gulf conflict and more recently, during the Kosovo air campaign, the US military

the Gulf War that they became the centre of much attention and interest. These vehicles offer significantly increased capability over the smaller tactical UAVs in terms of payload (200 vs 500 lbs), endurance (3 vs 40 hours), range (108 vs 500 nautical miles) and ceiling (15,000 vs 25,000 feet). The most popular MAE UAV currently on the market is the American *Predator*. The third category, the high-altitude endurance UAV, currently comprises only one vehicle: the American *Global Hawk*.[79] This developmental vehicle has been designed to act as a high-altitude surveillance platform as well as a communication relay vehicle.

The UAV sensor suite varies between vehicles depending on the payload capacity and the role(s) assigned to the platform. At this point in time, UAVs only carry imagery collection sensors however, current plans for future sensor suite include such devices as electronic intelligence gathering sensors, radar jammers as well as chemical and biological weapon detectors. The three most common types of imaging sensors currently fitted are the photo/video camera operating in the visible portion of the electromagnetic spectrum, the infrared camera and the imaging radar. UAVs are also fitted with a sophisticated communication suite which allows reception of flight control information and transmission of collected imagery in real time via line of sight radio or satellite link. Tactical UAVs rely primarily on direct line of sight communications while long range high-altitude endurance UAVs are dependent on satellite communication links for flight controls and sensor downlinks.

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has decided to fund an aggressive research and development program to further their capabilities and expand their roles.

[79] Global Hawk's performance characteristics are as follows: endurance 40 hours, range 3000 nautical miles and ceiling 65,000 feet. In Kumar, Rajesh. "Tactical Reconnaissance: UAVs versus Manned Aircraft." Research paper – USAF Air Command and Staff College. March 1997. 9.

UAVs offer several advantages over other ISR platforms. First, and probably most important, is the fact that they do not carry personnel onboard. Given the current intolerance towards casualties in Western societies, this characteristic gives the UAV a significant edge over other ISR platforms. Secondly, UAVs are significantly less expensive to purchase than manned aircraft or satellites although, the cost of operation of large HAE UAVs might be comparable to that of a small size fighter aircraft. Finally, another important feature of UAVs is their ability to stay aloft for extended period. According to Kumar, two of the most popular American UAVs currently on the market, Predator and Global Hawk, are able to remain airborne for periods of over 40 hours.[80]

Although UAVs have the potential to become robust and highly capable multi-role platforms in the future, it is important to understand the weaknesses and deficiencies of the current generation of UAVs. Firstly, UAVs are highly vulnerable to low-level air defence and other rudimentary forms of attack. For instance during the Kosovo air campaign, Serb soldiers would fly helicopters along side the UAVs and blast the air vehicles using machine guns. According to NATO sources, the coalition lost 27 UAVs during the campaign.[81] Another significant limitation of UAVs lies in their control mode. If the UAV is operated in the autonomous (pre-programmed) mode without a data link, it loses its mission flexibility and there is no way of knowing if a mission has been successful until the vehicle returns. If on the other hand the UAV is remotely piloted via data link, the vehicle retains its mission flexibility but available satellite communication frequencies for flight control and data download become a significant problem. According to Ripley, modern UAVs controlled via satellite links consume significant portions of the available communication bandwidth allocated to UAV operations. This

[80] Kumar. 9.
[81] Ripley, Tim. "UAVs over Kosovo – Did the Earth Move?" Defence Systems Daily. 1 Dec 1999. 5, 8. http://defence-data.com/features/fpage34.htm

demand for bandwidth is further increased when real time imagery transmission requirements are added. Unless new and innovative ways of compressing data transmissions are developed in the near future, simultaneous employment of UAVs by a coalition force will be limited by the physical availability of satellite communication bandwidth.[82] In addition to these two weaknesses, UAVs are also susceptible to radio interference and jamming. Although the employment of sophisticated encrypted transmissions will probably reduce or eliminate the possibility of overriding command transmissions, UAVs will still be vulnerable to jamming. Finally UAV sensors, as for other ISR sensors, are affected by weather conditions such as clouds, rain and fog and like satellites, they are only able to provide imagery of the ground surface.

While the potential of UAVs cannot be ignored, it is important to realize that a lot of research and development are still required before UAVs are able to replace existing ISR platforms. As concluded by Ripley, "[W]hile the casualty free nature of the [Kosovo] air campaign has been hailed as a success by UAV proponents, many veterans of the Kosovo campaign are not convinced that UAVs are the answer to all future surveillance requirements."[83]

Manned Aircraft

The employment of manned aircraft in the airborne surveillance and reconnaissance role is a practice that goes back to the First World War when biplanes were first used to locate enemy troops and identify targets for artillery fire. Over the past century, surveillance aircraft have immensely benefited from advances in technology and

[82] Ripley, Tim. "The Data Link Challenge." Unmanned Vehicles. Aug 1997. 27, 28.
[83] Ripley. "UAVs over Kosovo – Did the Earth Move?" 8.

have evolved into a number of highly specialized intelligence gathering platforms able to operate effectively over long distances and in most weather conditions.

Three of the most prominent ISR manned platforms are the AWACS, JSTARS and RIVER JOINT aircraft.[84] As its name implies, the airborne warning and control system (AWACS) aircraft is an airborne air surveillance platform designed to provide the military commander airborne early warning as well as command and control capability over the air battle. Its surveillance radar can detect and track flying aircraft from the earth's surface to high altitudes and at ranges in excess of 200 miles, over land and water. The AWACS aircraft provides information for air defence, interdiction, reconnaissance, airlift and close air support for friendly ground forces as well as direct fighter-interceptor aircraft engaged in counter air missions. The AWACS aircraft is also being used extensively in support of other government agencies for counter drug operations and homeland defence.[85] The Joint Surveillance Target Attack Radar System (JSTARS) aircraft is a long-range, ground surveillance system designed to surveil, locate and track ground targets in all weather conditions. Using a sophisticated multi-mode, phased array radar, the JSTARS aircraft can detect moving ground targets to a range in excess of 150 miles and produce photographic-like images of ground targets as well as maps of selected geographic regions.[86] The third category of manned ISR platform is the US Air Force RIVET JOINT aircraft. This long-range, electronic surveillance aircraft is designed to intercept and analyze electronic and communication transmissions (ELINT and

[84] There are also many other aircraft capable of conducting ISR roles such as the American U2 reconnaissance aircraft, the US Navy EP-3E ARIES electronic reconnaissance and many others. Airborne reconnaissance can also be performed by a number of fighter aircraft properly fitted with the necessary camera pods. For the purpose of this essay, only the AWAC, JSTAR and RIVET JOINT aircraft will be discussed as they represent the broad spectrum of ISR capabilities found onboard manned aircraft.
[85] Federation of American Scientists (FAS) website. Military analysis network. E-3 Sentry (AWACS). http://www.fas.org/man/dod-101/sys/ac/e-3.htm.
[86] Federation of American Scientists (FAS) website. Military analysis network. Joint Surveillance Target Attack Radar System (Joint Starts). http://www.fas.org/irp/program/collect/jstars.htm.

COMINT) within a range of 150 miles. RIVET JOINT provides the military commander and friendly forces early warning of threatening activities as well as indications on the location of enemy or hostile forces.[87] It should be noted that these three surveillance aircraft are fitted with tactical data links giving them the ability to exchange information and forward collected intelligence data to ground control stations in real or near real time.

Manned aircraft have several advantages over UAVs and satellites. First of all, they are currently the most responsive and flexible ISR assets available to the military commander given their ability to fly long distances rapidly, remain on station for extended periods and be re-tasked to a new mission almost instantly. Unlike UAVs, they are normally fitted with an extensive threat warning and self-defence suite and the aircrew onboard are able to recognize and respond to changing conditions, thereby increasing the platform survivability in a hostile theatre. Manned aircraft are also sufficiently large to be fitted with sensors (and power unit, cooling, etc) powerful enough to operate from stand off distances thereby allowing the aircraft to operate at safe distances. Finally, manned aircraft in ISR roles are fitted with a complete communication suite allowing them to operate as battle management and command and control platforms.

Despite their many advantages, manned aircraft also have a number of weaknesses. Firstly, they are currently not very stealthy platforms and in the case of the AWACS and JSTARS, the fact that they continuously transmit electromagnetic emissions makes them easily detectable targets subject to attacks by enemy long-range missiles and fighter aircraft. Secondly, large manned aircraft like the AWACS and JSTARS are expensive assets to acquire and operate. There are however a number of

[87] Federation of American Scientists (FAS) website. Military analysis network. RIVET JOINT.

smaller and less expensive aircraft designed to fulfill these ISR roles such as the US Navy E-2C Hawkeye[88] as well as new, light weight imaging sensors that can be fitted to medium size aircraft. The retrofit of a ground imaging synthetic aperture radar to the US Navy P3 Orion is a good example of this option.

CANADA'S CURRENT ISR CAPABILITIES

With the notable exception of the NORAD defence line and some classified communication intelligence work, the development, fielding or exploitation of ISR assets in Canada has never been given a very high priority. According to an independent study conducted in the fall of 1999, "[T]he Canadian Air Force has virtually no organic ISR ability to detect, classify and identify ground targets."[89] Since this report was published, a number of high-level guidance documents have been drafted[90] and plans for the acquisition of a new imaging sensor for the CH146 Griffon helicopter have been staffed but the situation has generally remained unchanged: Canada has very few assets capable of providing meaningful ISR information.

Surveillance Satellites

Canada currently has no military surveillance satellite. It has however one civilian radar imaging satellite in orbit, RADARSAT 1, exploited exclusively by the

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http://www.fas.org/irp/program/collect/rivet_joint.htm.

[88] Federation of American Scientists (FAS) website. Military analysis network. E-2C Hawkeye. http://www.fas.org/man/dod-101/sys/ac/e-2.htm.

[89] Allan, S. *et al*. "Affordable ISR Alternatives for Application in the Canadian Air Force." In Intelligence, Surveillance and Reconnaissance: Air Symposium 2001 edited by Margueratt D. and English A. Canadian Forces College. Sep 2001. 34.

[90] An example of such draft document is the CF ISR Vision, currently being drafted by DJFC. Canada. Department of National Defence. "Canadian Forces Intelligence, Surveillance and Reconnaissance (ISR) Vision." DRAFT. (Ottawa: Directorate Joint Force Capabilities, Oct 2001)

commercial sector for remote sensing of the Earth's surface.[91] A second, more capable[92] imaging satellite - RADARSAT 2 - is planned for launch in 2004. Although the Department of National Defence has, on occasion, purchased RADARSAT imagery from the Canadian Space Agency (CSA) to help plan troop deployments abroad, there is no formal arrangement between the two organizations regarding the regular provision of imagery of the Canadian territory or other parts of the world.[93]

Unmanned Aerial Vehicles

Canada does not currently possess any UAVs. Although the acquisition of UAVs has been the subject of much discussion in Canadian military circles over the past few years, funds allocated for the acquisition of an unmanned aerial surveillance system have been deferred[94] and there has not been any firm commitment to date.

Manned Aircraft

Canada currently has, or will soon have, two aircraft fitted with ISR sensors and capable of performing limited ISR tasks: the CH146 Griffon tactical helicopter and the CP140 long range patrol aircraft.

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[91] Information concerning the roles and capabilities of RADARSAT 1 are found on the Canada Centre for Remote Sensing web site as well as on the Alaska SAR Facility (ASF) web site.
http://www.ccrs.nrcan.gc.ca/ccrs/tekrd/radarsat/specs/radovere.html
http://www.asf.alaska.edu/source_documents/radarsat_source.html

[92] RADARSAT 2 will provide radar imagery of higher resolution than its predecessor from ten meters for RADARSAT 1 down to three meters for RADARSAT 2. Information regarding the capabilities of RADARSAT 2 are found on the Canadian Space Agency web site.
http://www.space.gc.ca/csa_sectors…arsat2/rad_inf/tec_spe/default.asp

[93] Malo, Francois. Canadian Space Agency briefing. 4 Mar 2002.

[94] "Army Regrouping in Face of Cuts." Jane's Defence Weekly. 2 Feb 2000. 29.

The CH146 Griffon is a multi-purpose helicopter employed by the Canadian Army to perform troop and supply transport as well as area surveillance and reconnaissance. To carry out this latter role, the Army has recently identified the urgent requirement to equip its helicopters with an electro-optical sensor suite. This new Electro-optical Reconnaissance Surveillance and Target Acquisition (ERSTA) system will be comprised of an infrared and a visible spectrum camera, a laser range finder and a laser target designator. It will also include a tactical data link that will provide the capability to transmit reconnaissance and target data and imagery to a ground station.[95] The plan for the acquisition of the ERSTA system has recently been approved and delivery should take place over the next few years.

The CP140 Aurora is Canada's only long-range airborne surface and subsurface surveillance platform. Acquired in the early 1980's, this aircraft was designed primarily as an anti-submarine warfare (ASW) platform but given its well-suited sensor suite for land surveillance roles, the aircraft was routinely assigned to surveillance missions in Canadian northern territories and coastal waters. In addition to acoustic sensors employed in underwater surveillance, the aircraft is fitted with a surface search radar, a forward looking infra-red (FLIR) camera and an electronic emissions receiver (also known as Electronic Support Measures or ESM). In December 2000, the Department of National Defence initiated an extensive modernization program, the Aurora Incremental Modernization Program (AIMP), to replace outdated and unsupportable sensors and consequently "restore the operational effectiveness of the CP140."[96] Amongst the new systems required are an imaging radar (with moving target detection capability), a multi-

[95] Canada. Department of National Defence. "Canadian Forces Utility Tactical Transport Helicopter Project A2517 – Electro-optical Reconnaissance, Surveillance and Target Acquisition (ERSTA) System." Operational Requirement Description. (Ottawa: DND Canada, circa 1999).
[96] Canada. Department of National Defence. "Master Implementation Plan for the CP140 Aurora Incremental Modernization Project - AIMP." (Ottawa, National Defence Headquarters, 28 Feb 2001). 1.

spectral electro-optical system, a modern ESM system and a defensive electronic warfare system (DEWS). A detailed description of the new sensors and communication suite identified in the CP140 AIMP Statement of Operational Requirements (SOR) is found at Annex A.

As it stand, Canada does not have very much ISR capability to offer to a coalition force nor does it have the ability to become an integrated element of the American system of systems. Although a few ISR acquisition programs have been launched, the lack of clearly defined national requirements is a serious obstacle to the development and implementation of a much needed capability. The next section will examine and attempt to define Canada's national ISR requirements.

V. CANADA'S ISR NEEDS

In the foregoing discussion, it was established that the selection of ISR as a niche capability for Canada was based on not only economic and political factors, but also on the ability of this niche capability to contribute to future coalition efforts as well as meet the specific ISR needs of Canada. Before addressing the latter part of this statement, the question of value of a Canadian ISR capability to a coalition should be examined. The answer to this question was provided during the 1999 Kosovo air campaign. During this campaign, the demand for ISR was so great that the US military had to re-allocate AWACS, JSTARS and UAVs from other commands to the Kosovo theatre of operation.[97] The British and American post-action reports referred to ISR platforms as "low-density high demand" assets. The Kosovo campaign clearly demonstrated the importance and value of ISR assets in the conduct of military operations and there is no reason to believe that this demand will decrease in the future.[98] The addition of Canadian ISR assets to those already available to the coalition would certainly constitute a meaningful contribution given the significant demand placed upon these highly valuable platforms. The second and more challenging question to address is the Canadian need for ISR. To answer this question, it is necessary to examine and identify ISR requirements based on the three Canadian defence missions.

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[97] United States. Department of Defense. "Operations in Kosovo: Problems Encountered, Lessons Learned and Reconstitution." Hearing of the US Armed Services Committee 26 Oct 1999. (Washington D.C. US Government Printing Office, 2000). 19.

[98] According to a Federation of American Scientist (FAS) study, more JSTARS aircraft than initially planned will be required when conducting operations in mountainous areas. "Planners initially believed that three continuous orbits would cover the theatre of a major theatre of war. But experience in Bosnia's mountainous terrain suggests even smaller operations might require more than three continuously orbiting aircraft." In Federation of American Scientists (FAS) website. Military Analysis Network. Joint

DEFENCE MISSION 1: CANADIAN SOVEREIGNTY

Surveillance over Canadian Territory

The surveillance of the Canadian territory and coastal waters is a matter of national interest and sovereignty. Every year, several occurrences of illegal or unauthorized activities are reported but many more are not due to a lack of adequate surveillance capabilities. Illegal immigration, drug smuggling, pollution, illegal fishing and unauthorized presence in northern areas are all significant issues that threaten Canadian sovereignty. The difficulty in achieving adequate surveillance of the Canadian territory comes in large part from its considerable size which equates to approximately 9.9 million square kilometres of territorial land and waters.[99]

Over the years, a number of surveillance options have been trialed with limited success. Surveillance by ships offers the advantages of continuous presence as well as the ability to conduct subsurface surveillance. However, given the time taken by a naval vessel to surveil any significant amount of surface area and the difficulty in manoeuvring in the northern waters due to the presence of arctic ice during several months, a more rapid and efficient option was required. Surveillance from the air has proven to be much more successful but still, given the time required for a UAV or an aircraft like the CP140

Surveillance Target Attack Radar System (Joint STARS).
http://www.fas.org/irp/program/collect/jstars.htm. 5.

[99] United States. Central Intelligence Agency. "The World Factbook 2001."
http://www.cia.gov/cia/publications/factbook/

Aurora to complete a full surface surveillance sweep of the Canadian territory - in the order of weeks[100] - this option was also discarded as it does not provide timely results.

A third and more promising option resides in the exploitation of space-based surveillance satellites. An imaging satellite would provide periodic coverage of the Canadian landmass and territorial waters. According to the CSA, "RADARSAT 1 can provide daily coverage of the Arctic, view any part of Canada within three days, and achieve complete coverage at equatorial latitudes every six days…."[101] Although surveillance satellites do represent the most promising option for periodic surveillance, they would also have to be complemented by other ISR assets. As discussed previously, one weakness of surveillance satellite is that, although timely for the detection of slow changes, they are not capable of detecting rapidly changing situations like the short and illegal incursion of foreign fishing vessels in Canadian waters. Also, they are incapable of conducting underwater surveillance. ISR assets like the CP140 or possibly a MAE UAV would therefore still be required to perform tasks not well suited for satellite surveillance.

Aid to the Civil Power

A second aspect of this defence mission is the provision of aid to the civil powers. The Canadian Forces have been requested on several occasions in the past to provide support during national emergencies whether these were caused by natural events such as floods or ice storms or the result of public disorder like to Oka crisis. In most cases, the

[100] For instance, Matte calculated that it would take a single CP140 Aurora over 200 hours to complete one full surface surveillance sweep of Canada's ocean area of responsibility. In Matte, P.R. "Canadian Sovereignty Through Surveillance: A Requirement for a National Space-Based Wide Area Surveillance Capability." Canadian Forces College. Exercise New Horizons. Mar 1994. 16.

support requested included the provision of airborne surveillance to measure and assess the extent of the situation or monitor the activities of suspected violators. For these missions, ISR assets in the form of UAVs, surveillance helicopters or manned surveillance aircraft are well suited although manned aircraft offer the added benefit of providing an airborne command and control capability.

DEFENCE MISSION 2: DEFENCE OF NORTH AMERICA

For the past fifty years, the surveillance of the Canadian airspace and the defence of North America against airborne threats have been the prime responsibility of NORAD. Using a sophisticated network of ground radars strategically located along the coastal borders, NORAD has been able to monitor the entry and departure of airborne traffic in and out of Canadian airspace and detect the presence of unauthorized or illegal aircraft attempting to enter Canadian airspace. Although quite impressive, the ability of the radar defence line to detect unauthorized entry into Canadian airspace is not perfect. Gaps between individual ground radars and the absence of radar stations along the West coast[102] have significantly weakened NORAD's detection capability. Furthermore, with the exception of a 200 mile band along the Eastern and Northern coasts, there are no radar coverage inside the Canadian territory. Once an aircraft has penetrated Canadian airspace and flown through the coastal radars, it is no longer tracked by NORAD.[103]

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[101] Canada Centre for Remote Sensing. RADARSAT 1 Overview. http://www.ccrs.nrcan.gc.ca/ccrs/tekrd/radarsat/specs/radovere.html

[102] As discussed by Malo, there are no ground radars along Canada's West coast. Under the 1985 Canada-US North Warning System (NWS) modernization program, a number of over-the-horizon backscatter (OTH-B) radars were to be installed on the West coast to provide the necessary coverage but this portion of the modernization program was later cancelled by the US Government. In Malo, Francois. "Canadian Aerospace Sovereignty: In Pursuit of a Comprehensive Capability." Canadian Forces College. Exercise New Horizons. May 1998. 4.

To strengthen Canada's ability to assure and maintain airspace sovereignty, the gap in the Western surveillance perimeter must obviously be closed by introducing additional ground radar stations and a capability to perform airspace surveillance inside the border must be acquired. The installation of an extensive network of radar stations covering the entire continent would likely achieve the desired results but its cost would be too prohibitive. The employment of surveillance satellites or UAVs to carry out aerospace surveillance is not an option as these ISR assets are not currently designed for or fitted with the proper sensors. A manned aircraft fitted with an airborne surveillance radar similar to that of the US AWACS or Hawkeye aircraft would provide the necessary surveillance capability. It would also significantly improve the Canadian Forces' ability to respond to an airborne threat by providing the situational awareness and the command and control needed by fighter aircraft during the conduct of intercepts: information not currently provided by NORAD when operating inside the Canadian border.

DEFENCE MISSION 3: INTERNATIONAL PEACE AND SECURITY

Over the past fifty years, Canada has been involved in a number of UN-sanctioned multinational military interventions aimed at restoring or enforcing international peace and security. Given Canada's commitment to international peace and security and the likelihood that similar interventions will be required in the future, the Canadian Forces must be adequately prepared to meet the challenges associated with these missions, whether these are peacekeeping, peace enforcement or combat operations in a theatre of war.

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[103] Stannix, LCol Ken. Commanding Officer. 21 Radar Squadron North Bay. Personal Interview 7 Mar 2002.

As demonstrated during military interventions in the Persian Gulf, Africa and the former Yugoslavia, ISR plays a critical role in providing timely intelligence data to friendly forces on the location and activities of opponents or conflicting parties. ISR requirements vary significantly depending on the type of operations and become increasingly greater as the intensity of the conflict increases. To better understand these requirements, each type of operation will be examined in turn.

Peacekeeping Operations

Traditional peacekeeping operations are, by definition, low intensity operations where UN forces are deployed to monitor a peace already agreed by the belligerents.[104] Given the relatively benign environment and the fact that organized opposition is unlikely, airborne ISR operations will normally be limited to aerial observation and general intelligence gathering. Typical Canadian peacekeeping missions requiring ISR support are:

> Pre-deployment survey - Initial survey of area of operational responsibility using satellite imagery and rapidly deployable manned aircraft fitted with an imaging radar and visual/infrared sensors.
>
> Monitoring cease-fire, separation/withdrawal of forces and movement of refugees - ISR requirements for these missions would take the form of area or sector surveillance using UAVs, helicopters or manned aircraft fitted with an imaging radar and visual/infrared sensors. The ISR platform should be able to remain airborne for long periods and fly over long distances to cover potentially

[104] Canada. Department of National Defence. "Canadian Forces Operations." (Ottawa: DND Canada, 1997). 10-4.

large areas of responsibility.

Protection of humanitarian aid convoys - ISR requirements for this task include area and route surveillance using UAVs, helicopters or manned aircraft fitted with an imaging radar and visual/infrared sensors.

In the 1990's, the profound changes in the global strategic environment resulting from the demise of the former Soviet Union have altered the character of traditional peacekeeping operations. Today's peacekeeping operations often involve a higher risk of casualties to deployed troops. Moreover, the volatility of the situation requires that deployed forces be adequately equipped to meet rapidly evolving situations. This fact was clearly demonstrated during recent peacekeeping operations in Somalia[105] and Bosnia.[106] ISR requirements in modern peacekeeping operations must now include a robust air and surface surveillance capability to warn troops in theatre of potential dangers and provide timely intelligence data for operations. ISR platforms required for these tasks include UAVs, helicopters and manned aircraft fitted with imaging radar and visible/infrared sensors as well as manned aircraft fitted with an air surveillance radar and an electronic emission receiver.

Peace Enforcement Operations

Peace enforcement operations are defined as "military operations to restore peace or to establish specified conditions in an area of conflict or tension where the parties may

[105] Rehbein. 25.
[106] As reported by Charters, "from 1992 to 1995, cease-fires came and went with almost daily regularity… the United Nations Protection Force (UNPROFOR) was operating in a war zone…" In Charters, David A. "Out of the Closet: Intelligence Support for Post-Modernist Peacekeeping." In Intelligence in Peacekeeping. The Pearson Papers, Paper Number 4. Canadian Peacekeeping Press. 1999. 40.

not consent to intervention and may be engaged in combat activities."[107] As shown during the peace enforcement operation in Kosovo in 1999, intervening forces will likely have to adopt an aggressive posture to separate belligerents and restore order while diplomatic actions are taken. Possible peace enforcement missions involving the Canadian Forces and their associated ISR requirements are as follows:

> Monitoring of troop movements – These essential intelligence gathering missions could be performed by UAVs or tactical helicopters but given the high risk and the necessity to probe deep inland, they should be performed by a manned aircraft fitted with a long-range imaging radar, visible/infrared sensors, electronic emissions receiver as well as communication and real time image transmission capability compatible with the equipment of land forces in theatre.
>
> Enforcement of economic sanctions and embargo – This type of mission requires a UAV, helicopter or manned aircraft fitted with an imaging radar and visible/infrared sensors as well as communication and image transmission capability compatible with Navy systems.
>
> Denial of airspace through enforcement of 'no-fly zones' – This type of mission requires a manned aircraft fitted with an air surveillance radar, electronic emissions receiver, communication and data link equipment compatible with fighter aircraft systems.
>
> Protection of civilian populations and refugees in 'safe areas' – These missions could be performed by a UAV, helicopter or manned aircraft fitted with an imaging radar, visible/infrared sensors, electronic emissions receiver, communication and real time image transmission capability compatible with land forces systems.

[107] Canadian Forces Operations. 10-4.

Protection of forces in theatre – These surveillance missions should be performed using UAVs, helicopters or manned aircraft fitted with imaging radar and visual/infrared sensors. A manned aircraft equipped with an air surveillance radar, electronic emissions receiver, communication and data link compatible with fighter aircraft systems is also required.

Combat Operations in Theatre of War

In 1991, the Canadian Forces participated in combat operations against Iraqi forces during the Gulf War and the possibility of a similar international military conflict in the future can unfortunately not be discarded. Combat operations against a well-trained and equipped military opponent will require the aggressive exploitation of all ISR assets to gain the initiative and achieve military success. Typical missions which could be conducted during combat operations include many of those performed during peace enforcement operations as well as the following:

Littoral area sanitization - Before deploying forces into a theatre of operation, the sea lines of communication and the coastal waters (surface and subsurface) must be searched and the area sanitized to ensure the security of incoming naval forces. ISR requirements for this mission include imaging radar and visual/infrared sensors, acoustic detection sensors as well as communication and data link capability with naval forces and national operations centre.

Offensive and defensive counter air – ISR requirements for these types of operations include an AEW&C-type aircraft to direct and control fighter aircraft. This manned aircraft will be fitted with an air surveillance radar, electronic emissions receiver as well as communication and data link capability compatible with fighter aircraft and the air operations centre.

Strategic offensive and air interdiction operations - ISR requirements for these missions include stand off search, identification and reporting of land targets using manned aircraft fitted with long-range imaging radar, visual/infrared sensors, electronic emissions receiver as well as real time image transmission capability compatible with land forces and the air operations centre.

Anti-surface and anti-subsurface operations – ISR requirement for these missions is a manned aircraft capable of conducting search, identification and reporting of surface and subsurface targets using imaging radar, visual/infrared sensors and acoustic detection sensors as well as communication and real time data link capability compatible with naval forces and the air operations centre.

Battle damage assessment – ISR requirement for this mission include UAVs or manned aircraft fitted with long-range imaging radar, visible/infrared sensors and real time image transmission capability with the air operations centre.

ISR NEEDS: FILLING THE GAPS

The foregoing examination reveals that Canada's ISR requirements are indeed quite significant and encompass a wide spectrum of activities ranging from periodic surveillance of territorial land and waters to detection and identification of hostile airborne and submerged combatant units in a theatre of war. However, as discussed in the previous section, Canada clearly does not have the ISR assets necessary to meet these requirements.

To perform periodic surveillance of the Canadian territory and obtain pre-deployment strategic intelligence on specific areas of interest, a space-based imaging satellite is the best-suited option. Given that Canada will not likely invest in military

imaging satellites, the Canadian Forces must secure direct and continuous access to Canadian commercial satellite imagery from RADARSAT.

To conduct ground surveillance during domestic and peacekeeping operations where the risk of casualties is relatively low, the CP140 Aurora might be used, especially if there is a requirement for an airborne command and control capability. However for most missions of these types, a properly fitted helicopter such as the CH146 Griffon with the ERSTA system or a MAE UAV will be more than adequa

number of options are available. Given the current funding limitation and fleet downsizing and rationalization initiatives, the logical option is to modify an existing and suitable Canadian Forces aircraft: the CP140 AIMP. This option, as well as the shortcomings of the CP140 AIMP in performing ground surveillance missions in support of land forces, will be discussed in the following section.

VI. CP140 AIMP IN ISR ROLES: CAPABILITIES AND SHORTCOMINGS

Upon completion of its modernization program, the CP140 AIMP will have effectively outgrown the ASW mission for which it was originally designed. Its potential as an airborne surveillance and intelligence collection platform was recognized shortly after it entered service in the 1980's however, the limited capability of some of its surveillance sensors[108] and the absence of a real requirement for airborne ISR, as it currently exists in the post Cold War era, did not require further development or exploitation of this capability. The modernization program will give the Aurora a significantly improved capability to carry out surveillance missions but the proposed improvements are insufficient as they were not intended to meet Canadian Forces ISR requirements.

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CP140 AIMP IN MARITIME ISR ROLE

As discussed previously in this essay, the maritime ISR requirements are focused primarily on surface and subsurface surveillance to detect, identify, track and report all contacts to a supported naval force and the national operations centre. Not surprisingly, the CP140 AIMP will be well suited to accomplish these tasks given that the AIMP SOR was developed based on current CP140 capabilities and roles. The new state-of-the-art acoustic detection system will provide the needed subsurface surveillance capability and the new long range imaging radar will allow surveillance, detection and identification of surface contacts while remaining well outside enemy weapon engagement zones. The AIMP communication suite will be optimized for maritime operations and will include a data link system which should be compatible with naval platforms although this still remains to be confirmed.[110]

CP140 AIMP IN LAND ISR ROLE

The CP140 AIMP will be fitted with many of the sensors and communication equipment required to perform land surveillance and intelligence gathering roles during international peace and security missions but will still be lacking in some important areas. The new imaging radar will provide the long-range search, detection and identification capability required and the new electronic emissions receiver should be capable of providing identification of ground emitters from safe distances. The new electro-optical system however will be unsuitable for operation in medium or high intensity conflict as

[110] As noted at Annex A, the requirements for the data link system have been purposely written in general terms thereby allowing potential bidders to propose their own solution. This approach is not ideal as there are three possible options for data link: link 11 (used by Canadian Navy and other maritime forces), link 16 (used by US AWACS, JSTARS and fighter aircraft) and link 22 (a new system under development). Given that link 22 is still a long ways from fielding, the CP140 ISR may require both link 11 and link 16.

the stated range requirement is insufficient.[111] In the land environment, the CP140 AIMP will not only be confronted by short range infrared missiles (as stated in the SOR) but will also have to remain outside the range of low-level air defence systems and area defence surface-to-air missiles (SAM). These systems can achieve ranges of 9 and 25 kilometres respectively as opposed to only 5 kilometres for typical shoulder-launched infrared missiles. [112]

The selection of appropriate communication and data link systems for the CP140 AIMP involved in supporting land operation will be a challenging task. Although the AIMP SOR identifies the requirement for compatible radios with the Canadian Army, the problem is that the new Army communication equipment (i.e. the Tactical Command, Control and Communication System – TCCCS) is currently not compatible with that of other services. As reported by Martyn, "TCCCS is not interoperable with any communication systems in the Canadian air force or navy, or any of our NATO allies' services."[113] Furthermore, according to LCol McLeish, a staff member in the Directorate of Army Doctrine, the Canadian Army has not yet selected which tactical data link it intends to use for air-to-ground transmissions.[114] Further work in this area will be required before an operational capability can be fielded.

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[111] The stated range requirements for the new electro-optical system is that of shoulder-launched infrared missiles which typically equates to 5 kilometres. See Annex A.
[112] CH146 ERSTA Statement of Requirements. 13.
[113] Martyn, Robert. "The Revolution in Military Affairs: Is the Emperor Ready for His New Clothes?" In Intelligence, Surveillance and Reconnaissance edited by Margueratt, D and English A. Canadian Forces College. Air Symposium 2001. 133.
[114] LCol McLeish also indicated that, because the choice of a data link had not yet been made by the Army, the data link portion of the CH146 Griffon ERSTA project was on hold. In McLeish, R. Presentation to CFCSC on Canadian Tactical Aviation. 8 Mar 2002.

CP140 AIMP IN AIR ISR ROLES

As was abundantly demonstrated in the previous section, Canada has a significant requirement for an air surveillance capability. National airspace sovereignty and air defence missions are seriously lacking a critical capability while international peace and security missions, such as peace enforcement missions and combat operations, would immensely benefit from the real time information and command and control capability that can only be provided by an AEW&C platform.

A cost-effective solution to provide Canada with an AEW&C capability is to modify the CP140 for the AEW&C role. To accomplish this, a few options are available. The simplest and less risky option from a technical perspective involves the fitting of the US Navy Hawkeye air surveillance radar to the CP140. This option in fact already exists and has been in service for over a decade with the US Customs Services in the counter drug role (Figure 1). The Hawkeye air surveillance radar is a proven system which has clearly demonstrated its operational capabilities during the US bombing raid against Libya in 1986.[115] A second option involves fitting a more modern phased-array radar to the CP140 such as the new Swedish *Erieye* air surveillance radar. This radar, currently fitted to the Brazilian Embraer ERJ-145 regional jet (Figure 2), is now in service with the Swedish air force and under production for the Brazilian and Greek air forces. A third, more risky option would involve contracting out the development and production of an air surveillance radar for the CP140 to a Canadian aerospace company with proven expertise in the field.

[115] The E-2C Hawkeye directed the F-14 Tomcat fighters that provided combat air patrol during the joint strike against Libyan targets in 1986. During this raid, American fighter aircraft made 153 intercepts of Libyan air force attempting to overfly the US fleet or intercept the US fighter combat air patrol. In Federation of American Scientists (FAS) web site. "E-2C Hawkeye." Military Analysis Network. http://www.fas.org/man/dod-101/sys/ac/e-2.htm

Figure 1. US Customs Services P3 AEW&C

Figure 2. Embraer ERJ-145 fitted with the Erieye AEW&C radar

GROUND SUPPORT REQUIREMENTS FOR THE CP140 ISR

The current CP140 mission support and analysis infrastructure was designed to support maritime operations. As such, it provides excellent analysis capabilities for underwater acoustic data and limited capabilities for photo and electronic emission analysis. With the introduction of the new imaging radar, electronic emissions receiver (i.e. ESM) and defensive electronic warfare system (DEWS), the mission support and analysis capabilities will have to be expanded significantly. According to Oxlee, interpretation of radar imagery differs significantly from that of regular photography. In his book on aerial reconnaissance, Oxlee indicated that "there are a number of important differences in the interpretation of radar images and the techniques have to be learned…." Furthermore, he suggested that "[T]here is a large investment to be made in training if the results are to justify the cost of radar reconnaissance systems."[116] A dedicated image analysis centre and a number of trained specialists will be required to enable the exploitation of this capability.

The second area requiring new ground support capability is in the analysis of electronic emissions. Because of the limited operational capability of the electronic emission receiver (ESM) currently fitted to the Aurora, no significant expertise in this area was ever developed. With the introduction of a new, high-performance ESM receiver and a Radar Warning Receiver (RWR - a component of the DEWS), a dedicated electronic emission analysis centre and a number of analysis specialists will be required to perform post-flight analysis, data library update and reprogramming of threat files in the ESM and RWR receivers.

[116] Oxlee. 130.

DOCTRINE AND ORGANIZATION

The introduction into service of an ISR capability will require the formation of a new type of aircrew, specialized in the planning and execution of intelligence gathering and surveillance missions and in the skilful employment and exploitation of on board imaging sensors. Since most of the ISR missions will be conducted in direct support of land force units (in the case of the CP140 AIMP-ISR) or air force fighter aircraft (in the case of the CP140 AEW&C), the crews will routinely practice their skills with those units as opposed to working with the Canadian Navy in the maritime environment. Doctrinal and procedural documents describing ISR operations in support of land and air units will have to be drafted. Just as ASW, ISR will become a specialized area of expertise, requiring rigorous training and continuous practice.

In practical terms, the exploitation and nurturing of this new capability will be best achieved in the context of an independent, specialized squadron. Considering the reduced requirement for ASW-capable, maritime patrol forces in the current post Cold War era, serious consideration should be given to converting one of the three maritime patrol squadrons into an ISR squadron. This new squadron will become a centre of expertise for ISR and will therefore be the ideal breeding ground for junior aircrew. More importantly, the creation of an independent squadron will minimize the costs associated with the training of ASW and ISR-capable forces in terms of both time and money: two scarce resources which will likely continue to be critical in the foreseeable future.

THE FUTURE: CP140 ISR IN LAND ATTACK ROLE

One of the significant difficulties that have challenged military commanders during the Gulf War and, to a lesser extent during the Kosovo air campaign, has been the detection and the subsequent destruction of mobile targets such as SCUD missiles. These mobile targets tend to appear and disappear very rapidly thereby leaving coalition forces little or no time to carry out an attack once they have been detected by an ISR platform. In order to be successful in detecting and destroying these time-sensitive targets, the time between detection and attack must be minimized. The current US objective is to execute the detection to attack cycle, or in military jargon the sensor-to-shooter cycle, in less than ten minutes.[117]

Over the past decade, the US military has been experimenting with a number of options to achieve shorter sensor-to-shooter cycle. One approach has been to mount an air-to-surface missile directly onto a MAE UAV thereby reducing significantly the time from detection to engagement.[118] Although promising, this effort is still in the early stages of development and its future will be strongly associated with the development of more capable combat UAVs, currently under development in the US. A second and more promising approach has been the employment of the P3 Orion (the US counterpart to the Canadian Aurora) as a sensor-shooter platform. Fitted with an advanced imaging radar and long range air-to-surface missiles, this land attack aircraft demonstrated the ability to

[117] Ten minutes corresponds approximately to the average time it takes a mobile SCUD launcher to close its vertical launcher and ready the vehicle for movement.
[118] Baker, Sue. "RQ-1 Predator Hellfire Missile Tests Totally Successful." Aeronautical Systems Centre Public Affair. 26 Feb 2001.
http://www.ga.com/news/RQ-1.html

detect time-sensitive targets and carry out a simulated attack under ten minutes.[119] Could this be a future role for the Canadian CP140 ISR ?

[119] Fulghum, David. "Navy Claims Victories in Mobile Target Chase." Aviation Week and Space Technology. 2001.
http://www.aviationnow.com/content/publication/awst/20010730/avi_stor.htm

VII. SUMMARY AND CONCLUSION

As Canada enters the 21st century, challenges and uncertainties are paving the way ahead. One of the most important external influences that will impact and shape the future of the Canadian Forces is the American-led RMA. This revolution promises greatly improved military effectiveness but its cost may be out of the reach of most middle power countries such as Canada. A more realistic approach to the RMA consists in selecting a niche capability that would complement the capabilities of an international military coalition while providing a valuable national capability. An analysis of the niche capabilities supporting the RMA revealed that ISR is the best and most profitable niche capability for Canada.

ISR, along with C^4I and precision weapons, constitutes a key component of the US military 'system of systems'. It comprises all the intelligence gathering sensors currently available to the US military that collect data on the battlefield and forward it in real time to advanced data processing stations for rapid analysis and redistribution to the forces in the field. The three most important types of sensors in the system of systems are the surveillance satellites, the UAVs and the manned surveillance aircraft such as the AWACS, JSTARS and Rivet Joint. Canada currently has very few ISR assets that could contribute to a coalition effort. It has no military surveillance satellite, no UAVs and a limited airborne surveillance capability in the form of the CH146 Griffon and the CP140 Aurora.

In order to determine Canada's ISR needs, the three Canadian defence missions were examined. Significant gaps were identified in the Canadian Forces' ability to

conduct routine surveillance over the Canadian territory and to perform continuous surveillance of the Canadian airspace and particularly inside the territorial boundaries where there are no ground radars. A significantly large number of additional deficiencies were also identified in the Canadian Forces' ability to provide needed ISR support during peacekeeping, peace enforcement and combat operations.

To rectify these serious shortcomings, a sequential approach has been highlighted. A direct and continuous access to RADARSAT imagery should first be secured to provide a capability to monitor and surveil the Canadian territory and territorial waters. A small number of MAE UAVs should next be acquired to provide the Canadian Forces the improved ability to conduct surveillance during domestic operations and low-intensity peacekeeping operations. For peacekeeping missions presenting a higher risk of escalation and for peace enforcement and combat operations, two types of manned surveillance aircraft are required: a land ISR platform fitted with multi-spectral imaging sensors and an AEW&C platform fitted with an air surveillance radar.

Given that Canada cannot afford the acquisition of new manned surveillance aircraft like the AWACS and JSTARS, the proposed solution consists in modifying and fitting the CP140 Aurora with the required sensors. The current Aurora incremental modification program will go a long way in introducing the needed sensors for the land ISR role but there are still a number of deficiencies that need to be addressed immediately while the aircraft is undergoing modification. A separate modification program to fit an air surveillance radar to the CP140 AIMP must also be initiated promptly to secure an adequate air surveillance capability for the Canadian Forces.[120]

[120] Serious considerations should be given to modifying the three CP140A Arcturus aircraft instead of retiring them as it is currently planned in order to maximize the number of CP140 AIMP assigned to maritime patrol and land ISR roles.

This essay has demonstrated that ISR is a key capability for operations in the battlespace of the 21st century and that Canada would gain immensely by the acquisition of such technology. The options presented here to acquire a suitable level of capability are feasible, proven and within Canadian financial means. It is now time to act.

> "Victory smiles upon those who anticipate the changes in the character of war not upon those who wait to adapt themselves after the changes occur."[121]
>
> - Giulio Douhet

[121] Aviation Quotes. http://www.nd.edu/~jmay/leadquos.html

LIST OF ABBREVIATIONS AND ACRONYMS

AEW&C	Airborne Early Warning & Control
AIMP	Aurora Incremental Modernization Program
ASTOR	Airborne Stand-off Radar
ASW	Anti-submarine warfare
AWACS	Airborne Warning And Control System
CF	Canadian Forces
CSA	Canadian Space Agency
C^4I	Command, Control, Communication, Computers and Intelligence
DoD	Department of Defense
DEWS	Defensive Electronic Warfare System
ERSTA	Electro-optical Reconnaissance, Surveillance and Target Acquisition
ESM	Electronic Support Measures
HAE UAV	High Altitude Endurance Unmanned Aerial Vehicle
ISR	Intelligence, Surveillance and Reconnaissance
JSTARS	Joint Surface Target Attack Radar System
MAE UAV	Medium Altitude Endurance Unmanned Aerial Vehicle
NATO	North Atlantic Treaty Organization
NORAD	North American Aerospace Defence
R&D	Research and Development
RMA	Revolution in Military Affairs
RWR	Radar Warning Receiver
SAR	Synthetic Aperture Radar
SOR	Statement of Operational Requirements
UAV	Unmanned Aerial Vehicle
UN	United Nations
US	United States
USAF	United States Air Force

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ANNEX A

CP140 AIMP SYSTEM REQUIREMENTS

This annex is an extract from the CP140 AIMP Statement of Operational Requirement describing the sensor and communication suite requirements for the CP140 AIMP. It should be noted that the material presented is limited to sensors and communication equipment relevant to the ISR function.

Radar

In addition to providing conventional modes of operation at ranges not less than currently provided for weather avoidance, navigation, detection and tracking of periscopes, masts and surface ships, it is essential that the radar:

a. allow classification of an unknown surface target, either moving or stationary, at maximum radar range for the corresponding aircraft altitude while maintaining safe stand-off from long range surface-to-air missiles;

b. provide continuous and snapshot radar images of a selected ground track or location on either side of the aircraft for monitoring and classification of ground targets and facilities from a safe stand-off distance;

c. provide onboard processing, reprocessing and recording of radar data;

d. provide Ground and Sea Moving Target Indication (GMTI and SMTI);

e. provide enhanced small target detection;

f. allow for detection of airborne targets;

g. be capable of limited operation independently of the mission computer.

Electronic Support Measures (ESM)

The ESM system must be capable of searching for, detecting, localizing, tracking, analyzing, identifying, recording and displaying electronic emissions from air, sea (surface/subsurface) and land-based emitters.

Electro-Optics (EO)

It is essential that the Aurora have a multi-spectral system that can be used to search, detect, localize, classify, track, identify, and record contacts of interests (including submarine masts and periscopes). The system shall be capable of covert identification while remaining outside the effective range of infrared missiles and small arms weapons of 0.50 calibre or less. This includes ambient light conditions ranging from direct unobscured sunlight to overcast starlight in environment conditions to include fog, rain, drizzle, snow and high humidity. The system must be capable of limited operation independently of the mission computer.

Communication Suite

It is essential that the Aurora be capable of strategic and tactical communications with joint or combined co-operating forces and control agencies. The communication suite shall maintain, as a minimum, all existing capabilities and modes of communication, including but not limited to, direction finding, homing, frequency coverage, ICS [intercom system] channel selectivity, voice activated and recording of selected radio stations. The recording capability shall be provided to maintain, as a minimum, the existing recording capabilities. The communication sub-system shall include the following frequency bands and capabilities:

a. an internal communication system (ICS);

b. Ultra High Frequency (UHF) radios capable of plain and secure, voice and data communication with jam resistance and frequency hopping (such as Have Quick II);

c. Very High Frequency/Amplitude Modulated (VHF/AM);

d. VHF/Frequency Modulated (VHF/FM) radio capable of voice communication on marine and army bands with Digital Selective Calling capability;

e. Over-the-horizon HF that includes plain and secure voice/data capabilities;

f. Military SATCOM that includes plain and secure voice/data capabilities; and

g. Provision for growth to automatic radio transmission relay (AUTOCAT) if the capability is deemed necessary.

Full control of all radios must be available at the Pilot, Co-Pilot, NavCom and TacNav stations. A real time transmission capability that is interoperable with joint and combined forces shall form part of the communication suite for transmission of still and video and sensor data over both LOS and BLOS radios.

Tactical Data Link (TDL)

The TDL system must be capable of providing real time, multiple access, high capacity, jam resistant digital data, imagery and secure information to a variety of platforms. A ground-based test capacity at both main operating bases must exist. The TDL must be interoperable and able to support national and allied assets in joint and combined operations for a world-wide mandate with the capability to integrate data into a recognizable Maritime Picture or Common Operating Picture.

Defensive Electronic Warfare Systems (DEWS)

In order to improve the tasking flexibility of the Aurora it is essential that the aircraft be equipped a DEWS capable of:

a. detecting threat systems …;

b. indicating to the crew, via visual and audible means, the urgency posed by the detected threat; and

c. activating via automatic and manual means, a suitable defensive countermeasure to counter prioritized threats; the priority of which shall be from highest to lowest.