

Report on Canada, National Security and Outer Space

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EXECUTIVE SUMMARY

This report, commissioned by the Canadian Defence and Foreign Affairs Institute (CDFAI), details the findings and recommendations of a year-long study on the Canadian security implications of national and global civil, military, and commercial space trends.

Space is home to a host of activities that have roots dating back to the earliest days of space flight. Space is the transit route for ballistic missiles and the upper limits of ballistic missile defence. At the same time, space is the perch for some 700 orbiting satellites providing vital remote-sensing, navigation, timing, and communication services to a growing list of civilian and military users alike. Further, space is the heaven's gate for scientists and explorers around the world to venture into the unknown and answer some of humanity's foremost questions. **A notable expansion of players, interests, and capabilities has taken place in all of these arenas over the last fifteen years, a phenomenon that will no doubt continue to grow. However, Canada's space interest, investment, and understanding have not kept pace over the same period. On the contrary, they have arguably lessened, as has Canada's security vis-à-vis space.** This is a security vulnerability poised to deteriorate even more than it has thus far.

Nations must soon make important choices in order to ensure that the national security, safety, and well-being of their citizens are not endangered as a function of the manner in which outer space is, and will continue to be, exploited. Space security issues cover a wide spectrum of matters, ranging from the access to, and management of, space itself; to the access, use, and security of vital, space-based services (for example, remote sensing, communications, and navigation); through to the potential of defending against threats transiting through, supported by, or existing in space. Similarly, security issues range from traditional military concerns, through national sovereignty and the economy, to the environment. **Space has been a national security issue for Canada for fifty years, but this matter's complexity and critical importance has never been greater than they are now. Despite this somewhat alarming state of affairs, Canadians today remain largely unaware of the growing security reality, and Canada, as a nation, is disturbingly unprepared for its future in terms of space security matters.**

Specific Canadian findings include:

- Canada has no overarching national space policy, and space is not addressed in either of the latest national security and defence policies;
- Space is so structurally buried and fragmented within government that voices advocating for more appropriate treatment of space security issues are marginalized, even within such departments as Industry Canada (the Canadian Space Agency's parent department) and the Department of National Defence (DND);
- The Canadian Space Agency's (CSA) budget, and accordingly, its interests and activities have been diminishing and narrowing around space science and exploration for the last decade (dominated by human space flight and international space station programs), leaving little investment opportunity for other space pursuits (i.e., space-based services and access to space);
- The DND, while pursuing the development of a small space-surveillance satellite (Project Sapphire), has progressively scaled back its space interests and pursuits since its mid-1990s peak. Even then, those interests and pursuits were modest, end-user focused, and highly reliant on American leadership and resources;

- Canada's defence and security understanding and strategy with regard to space, as these are embodied in the Department of Foreign Affairs and International Trade (DFAIT) and DND, remain ensnared in historic Cold War paradigms and imperatives; in dated perceptions of space access, utilization, and weaponization, and in reliance upon the United States in terms of Canada's security and sovereignty interests;
- While Canada's dependency on space-based services is steadily growing, it has limited control or influence over the provision of those services, relying heavily on the services, and thus inevitably on the goodwill, of others;
- Canada's space industry is generally skewed towards end-user or ground segment needs and sub-system technologies, with thin and diminishing capabilities in space access and satellite design;
- Canada's space industry is highly reliant on, and vulnerable to, foreign export sales; and
- Canada's intellectual space expertise is limited, and public space perceptions and understandings are narrow and skewed towards human space flight and scientific exploits.

If Canada's space trajectory continues, the coming two decades will likely witness two contradictory trends in Canada. Space use and reliance will progressively increase, while Canada's public and private domestic capacity to ensure its space presence will decline. Access and security concerns will also increase, but Canada's real influence in the space domain's future development will diminish. Space has a particularly deep impact on the Canadian economy, as it does on the rest of the world's most advanced economies. That impact will only increase in the years ahead, as will Canada's dependency, and arguably, its vulnerability.

This report recommends that the Government of Canada establish an independent commission to examine space and to develop an updated and integrated national security space policy and strategy. Further, it recommends that:

From Chapter 1 —

- The Government of Canada recognize that outer space and the services derived from satellites constitute a growing national security issue for the safety and well-being of Canadians; and
- National security be the central focus of any review of Canadian national space policy and strategy.

From Chapter 2 —

- National space investment, which has been flat for the past fifteen years, be substantially increased;
- Further space exploration investments be curbed, unless advanced technology and foreign policy gains are overwhelmingly present;
- Space utilization initiatives and research and development be expanded, starting with the follow-up to Radarsat II, Project Epsilon II; and

- Space access be re-visited, particularly considering evolving air-launch and small-satellite-launch technologies, as well as their operational and foreign policy cost/benefits.

From Chapter 3 —

- Canada adopt a more regulatory approach to space security and weaponization, in order to more effectively impact today's unfolding global space realities;
- The DND renew its space policy and strategy; and
- The DND commit fully to Project Epsilon II.

From Chapter 4 —

- Space systems be recognized as critical infrastructure in Canadian security policy and contingency planning;
- Canada's space services and manufacturing industry be strengthened and rebalanced through selecting "developed and built in Canada" solutions wherever possible, and/or through strategic use of domestic and international public-to-public and public-to-private partnerships; and
- National space policy seek balance and synergy across national military, civil, and commercial interests and activities, and further, that it mandate, fund, and enforce the long-term, progressive growth of national space competencies.

From Chapter 5 —

- Canada's space advocacy be elevated and strengthened;
- The CSA be given independent representation in Cabinet and in relevant cabinet committees, including Foreign Affairs and National Security;
- Public Safety and Emergency Preparedness Canada (PSEPC) take the lead in establishing an inter-departmental working group on space security;
- The DND and the Department of Foreign Affairs and International Trade (DFAIT) establish dedicated Director-General space organizations; and
- CSA and DND jointly coordinate national space investments, ensuring the optimization and synergistic employment of Canadian civil and military space resources.

RÉSUMÉ

Le présent rapport, commandé à l'Université de Calgary par le Canadian Defence and Foreign Affairs Institute (CDFAI), expose en détail les constatations et les recommandations d'une étude d'un an sur les répercussions de l'évolution de l'espace civil, militaire et commercial, tant au plan national que mondial, sur la sécurité canadienne.

L'espace abrite tout un éventail d'activités dont les origines remontent au tout début des vols spatiaux. L'espace sert de chemin de transit aux missiles balistiques et aux limites supérieures de la défense contre les missiles balistiques. Dans un même temps, il sert de perchoir à quelque 700 satellites orbitaux qui fournissent des services essentiels de télédétection, de navigation, de synchronisation et de communication à une liste sans cesse croissante d'utilisateurs civils et militaires. De plus, l'espace est la porte du ciel utilisée par les scientifiques et les explorateurs dans le monde entier pour s'aventurer dans l'inconnu et répondre à quelques-unes des grandes questions que se pose l'humanité. **Une augmentation remarquable de protagonistes, d'intérêts et de capacités s'est produite dans tous ces secteurs au cours des 15 dernières années, un phénomène qui poursuivra sans aucun doute son essor. Cependant, les intérêts, les investissements et la compréhension du Canada dans le domaine de l'espace n'ont pas progressé à la même allure que le reste; bien au contraire, ils ont sans doute diminué, tout comme l'a fait la sécurité du Canada vis-à-vis de l'espace.** Il s'agit d'une vulnérabilité au plan de la sécurité qui est sur le point de se détériorer encore davantage.

Les nations devront bientôt faire des choix importants pour veiller à ce que la sécurité nationale et le bien-être de leurs citoyens ne soient pas compromis à cause de la manière dont l'espace orbital est exploité, maintenant et dans l'avenir. Les enjeux de sécurité spatiale englobent un vaste éventail de sujets, qu'il s'agisse de l'accès et de la gestion de l'espace en soi, ou encore de l'accès, de l'utilisation et de la sécurité de services essentiels installés dans l'espace (comme la télédétection, les communications et la navigation), ou bien des possibilités de défense contre les menaces qui traversent l'espace, qui existent dans l'espace ou qui sont aidés par celui-ci. De même, les enjeux de sécurité portent sur les préoccupations militaires traditionnelles, sur la souveraineté nationale et l'économie, et sur l'environnement. **Depuis 50 ans, l'espace est un enjeu de sécurité nationale pour le Canada, mais la complexité et l'importance cruciale de ce sujet n'ont jamais été plus grandes que maintenant. Malgré cet état d'affaires plutôt alarmant, les Canadiens sont pratiquement inconscients de la réalité croissante de ce problème, et le Canada, en tant que nation, n'est pas préparé à son avenir en termes de sécurité spatiale, ce qui est inquiétant.**

Voici quelques constatations particulières au Canada :

- le Canada n'a aucune politique nationale globale en ce qui concerne l'espace, et ce sujet n'est abordé dans aucune des récentes politiques en matière de sécurité et de défense nationales;
- l'espace est tellement enfoui structurellement et fragmenté au sein du gouvernement que les voix recommandant un traitement plus approprié des enjeux de la sécurité dans l'espace sont marginalisées, même au sein de ministères comme Industrie Canada (le ministère d'attache de l'Agence spatiale canadienne) et le ministère de la Défense nationale (MDN);
- depuis 10 ans, le budget de l'Agence spatiale canadienne (ASC) et par conséquent, ses intérêts et ses activités, a diminué et s'est resserré autour de la science et de l'exploration spatiale (dominée par les vols spatiaux des astronautes et les programmes de la Station spatiale internationale), ce qui laisse peu de possibilités d'investissement dans d'autres recherches spatiales (comme les services installés dans l'espace et l'accès à l'espace);

- le MDN, tout en poursuivant le développement d'un petit satellite de surveillance de l'espace (Projet saphir), a progressivement réduit ses intérêts et ses recherches dans l'espace, depuis le sommet atteint au milieu des années 90. Et même à ce moment-là, ces intérêts et recherches étaient modestes, ciblés sur l'utilisateur final et largement dépendants du leadership et des ressources des États-Unis;
- la compréhension et la stratégie canadiennes en matière de défense et de sécurité spatiales, telles qu'elles sont exprimées par le ministère des Affaires étrangères et du Commerce international (MAECI) et le MDN, sont prises au piège des paradigmes et impératifs historiques de la guerre froide : une perception désuète de l'accès à l'espace, de l'utilisation et de l'arsenalisation de l'espace, et de la dépendance des intérêts canadiens en matière de sécurité et de souveraineté envers les États-Unis;
- bien que la dépendance du Canada envers les services installés dans l'espace ne fasse que s'accroître, le pays a un contrôle ou une influence limités sur la prestation de ces services, qui dépendent lourdement des services des autres, et par conséquent, inévitablement, de leur bon vouloir;
- l'industrie spatiale du Canada est généralement axée sur les besoins de l'utilisateur final ou des composantes terrestres, et les technologies des sous-systèmes, tandis que les capacités sont faibles et diminuent dans le secteur de l'accès spatial et de la conception des satellites;
- l'industrie spatiale du Canada dépend fortement des ventes à l'exportation vers les pays étrangers et elle est vulnérable à celles-ci;
- les compétences canadiennes en matière d'espace intellectuel sont limitées, et les perceptions et la compréhension par le public sont étroites et polarisées sur le vol spatial des humains et les exploits scientifiques.

Si la trajectoire spatiale du Canada se poursuit, les deux décennies à venir produiront probablement deux tendances contradictoires au pays. L'utilisation de l'espace et la dépendance envers celui-ci s'accroîtront progressivement, tandis que les capacités intérieures, publiques et privées, du Canada à assurer sa présence dans l'espace, iront en diminuant. Les préoccupations en matière d'accès et de sécurité augmenteront également, mais l'influence réelle du Canada sur le développement futur du domaine spatial diminuera. L'espace a un effet particulièrement profond sur l'économie canadienne, comme il l'a sur le reste des économies les plus avancées au monde. Ces répercussions ne feront que s'accroître au cours des années à venir, tout comme le feront la dépendance du Canada et sans doute, sa vulnérabilité.

Le présent rapport recommande que le gouvernement canadien établisse une commission indépendante qui examinera l'espace et mettra au point une politique et une stratégie de sécurité nationale sur l'espace, à jour et intégrée. De plus, il présente les recommandations suivantes :

dans le chapitre 1 —

- le gouvernement du Canada doit réaliser que l'espace orbital et les services provenant des satellites constituent un problème croissant de sécurité nationale pour la sécurité et le bien-être de la population canadienne;
- la sécurité nationale doit être la cible de tout examen de la politique et de la stratégie nationale canadienne à l'égard de l'espace;

dans le chapitre 2 —

- l'investissement dans l'espace national, qui est stationnaire depuis 15 ans, doit être considérablement accru;
- il faut réduire les investissements dans l'exploration spatiale, à moins d'avoir des preuves de gains massifs en matière de technologie et de politique étrangère;
- les initiatives et la recherche-développement dans l'utilisation de l'espace doivent être élargies, en commençant par le suivi du RADARSAT 2 et du projet Epsilon II;
- l'accès spatial doit être revisité, compte tenu tout particulièrement des technologies en évolution dans le secteur du lancement aéroporté et du lancement des petits satellites, ainsi que de leurs coûts-avantages opérationnels et au plan de la politique étrangère;

dans le chapitre 3 —

- le Canada doit adopter une approche plus réglementaire envers la sécurité et l'arsenalisation de l'espace, afin d'influer plus efficacement sur les réalités apparentes de l'espace mondial d'aujourd'hui;
- le MDN doit remanier sa politique et sa stratégie spatiales;
- le MDN doit s'engager complètement au projet Epsilon II;

dans le chapitre 4 —

- les systèmes spatiaux doivent être reconnus comme une infrastructure cruciale de la politique canadienne en matière de sécurité et de planification des mesures d'urgence;
- le secteur canadien des services spatiaux et de la fabrication de produits spatiaux doit être renforcé et rééquilibré par le biais de solutions « de conception et de fabrication canadiennes » dans la mesure du possible, ou par le biais de l'utilisation stratégique de partenariats public-privé ou public-public, nationaux et internationaux;
- la politique spatiale nationale doit chercher à établir l'équilibre et une synergie entre les intérêts et activités militaires, civils et commerciaux au pays, et doit de plus, mandater, financer et faire valoir l'essor progressif et à long terme des compétences spatiales nationales;

dans le chapitre 5 —

- la défense des intérêts spatiaux au Canada doit être renforcée et accrue;
- l'ASC doit obtenir une représentation indépendante au sein du Cabinet et au sein des comités du Cabinet pertinents, dont celui des Affaires étrangères et de la Sécurité nationale;
- Sécurité publique et Protection civile Canada (SPPCC) doit prendre les devants en établissant un groupe de travail interministériel sur la sécurité dans l'espace;

- le MDN et le ministère des Affaires étrangères et du Commerce international (MAECI) doivent établir des organisations spatiales spécialisées dotées d'un directeur général;
- l'ASC et le MDN doivent coordonner conjointement les investissements nationaux dans l'espace, en veillant à optimiser l'utilisation synergétique des ressources spatiales civiles et militaires du Canada.

PREFACE

In 1967, the Government of Canada issued its first, and in some senses only, systematic study of Canada and outer space. The *Upper Atmosphere and Space Programs in Canada* report, better known as the *Chapman Report* (1967), was premised upon a realistic evaluation of the state of space technology and the costs and benefits of various options available to Canada with respect to space. In implementing its recommendations, Canadian space policy and strategy was established and has largely remained static with what are arguably only minor deviations with the creation of the Canadian Space Agency (CSA) in 1989 and the formal re-emergence of space within the DND in the early 1990s.

Notwithstanding the release of a formal space strategy by the CSA in 2003, Canada's space strategy as it evolved since 1967 might best be summarized as follows: the rejection of a national launch capability in favour of obtaining launches on very favourable terms from other nations, primarily the United States; limited niche investments in national capabilities with a concentration upon communications, and later, remote sensing; an overall civil-commercial concentration using private-public partnerships to develop space services; an overall end-user approach within government; and maintaining assured and reliable access to American defence and military space to meet Canada's defence and security requirements and interests.

While Canada's strategy has remained relatively constant since the 1960s, the world of space has not. Technologies have matured. Today, there are over 700 satellites orbiting the earth, and over 9,000 objects are tracked on-orbit. The world of space-faring nations has grown immensely, and the number of first-order, space-faring nations (defined as states possessing the full range of space capabilities, including launch) has increased from two (the United States and the Soviet Union) to seven with the addition of China, Japan, India, Israel, and the France-European Space Agency. With the continuing proliferation of ballistic missile technologies, the commercial-civil diffusion of launch technologies, and the ongoing research and development of new and more efficient, reliable, and cost-effective launch and satellite technologies and concepts, the world is on the cusp of not only having more nations able to access space, but also of viable commercial space ventures emerging for both public and private access purposes such as tourism.

Whereas the world of space was once dominated almost exclusively by civil and defence interests and investments, a mature commercial industry now exists to support these interests and provide a range of vital services to modern economies and societies. Space and the services that satellites provide today have increasingly become a "centre of gravity" for modern military forces and a "critical infrastructure" for modern, advanced, information-based societies. The loss or systematic disruption of space services poses a significant and growing threat to nations today, and this significance will only grow in the future. On this basis alone, space is a national security concern that will continue to increase.

For Canada, space resides only on the outside margins of national security considerations. The DND, the DFAIT, and the CSA have paid attention and developed some initiatives related to space and Canadian national security, particularly since the end of the Cold War. However, all function in an environment devoid of an up-to-date national space policy and strategy within which national security is an important consideration. Instead, all operate on the basis of a strategy and policy developed in another era, making adjustments over time reflective of their individual organizational interests. The net result is a relatively uncoordinated approach to space that is informed by a past when national security was not considered a priority.

To this end, **this report strongly recommends that the Government of Canada establish an independent commission to examine space in order to develop an integrated national security strategy and policy with regard to Canada and space; one that reflects current conditions as it guides future developments.** To facilitate this goal, *Canada, National Security and Outer Space* presents the case for space to be considered a national security issue for Canada, now and in the future; it describes and critically evaluates past and current Canadian

space policy and strategy from a national security perspective; it places Canadian thinking and practices within a global context, and it seeks to raise the profile of space in Canada and amongst Canadians by providing a primer on space and a reference source for future critical research on space generally, and on Canada and space in particular. This report presents five chapters that reflect those goals.

The opening chapter presents the basic arguments for treating space as a national security issue, employing two categories the Government of Canada regularly uses to discern threats to national security – Canadians' safety and their well-being. The next three chapters outline the foundation of these arguments by examining the past, present, and future nature of global space and of Canada's place therein.

The second chapter examines technological aspects, principally the development of the three primary realms of space activity: access to the environment; the utilization of the environment for terrestrial purposes; and the exploration of the environment for scientific purposes.

Chapter 3 evaluates the significant role that defence considerations have, and that they will continue to perform as a significant driver in the development and exploitation of space. In so doing, three phases or periods of defence and military space are identified and examined: the Cold War era, dominated by strategic deterrence thinking and requirements; the post-Cold War era, in which space services emerged as crucial enablers for terrestrial military operations; and the coming era, in which space itself will become an independent domain of military operations.

The critical economic significance of space in relationship to the well-being of nations is examined in the fourth chapter. This analysis first looks at the extent and nature of the space industry globally and within Canada. It then briefly examines the world's major operators and their activities before it finally, and most importantly, outlines the critical nature of the three increasingly indispensable space services – remote sensing, communications, and navigation – required by a modern economic system like Canada's.

The report concludes with a direct look at the manner in which space has been managed and administered within Canada. It emphasizes the vital importance of re-structuring space management and administration, not only at the national level, but also with regard to relations amongst and between the four primary governmental actors concerned with national security and/or space – Public Safety and Emergency Preparedness Canada (PSEPC), National Defence (DND), Foreign Affairs (DEA), and CSA-Industry Canada.

Although it may be somewhat premature in view of our contention that it is vitally important that the Government of Canada undertake an independent national study of space from both a broad national policy and strategy perspective and from a narrower, national security viewpoint, this report, in addition to its overall recommendation to undertake such a study, provides a series of recommendations that should be directly considered in any development of an up-to-date national policy and strategy that addresses space using a framework of national security. It also provides three appendices for reference and research purposes. The reference segment (app. C) presents material directly accessed in the report's development, while the select bibliography lists materials we believe to be relevant to any further study of this complex issue. In addition to incorporating all of this material and other secondary sources, we conducted confidential interviews with key actors intimately familiar with the entire spectrum of space, both within and beyond Canada. We extend our deepest appreciation to all who contributed their views and their current understanding of space. In many ways, this research would not have been possible without their assistance. As always, any errors or omissions are the responsibility of the authors, and the views expressed herein are ours alone.

Finally, the authors would like to express their thanks to Dean Foster and Wilson Wong, whose research assistance proved invaluable for this study.

CHAPTER 1

CANADA, NATIONAL SECURITY AND SPACE UNDERSTANDING

Introduction

Security has traditionally been understood with direct reference to the state and to the issue of threats to the preservation of a nation's territory, institutions, and way of life (Buzan 1983). As such, the dominant manifestation of the concept has been national security (as opposed to other manifestations like human security). While there is some tension between national and human security, the two are inherently intertwined. The state provides security to its citizens, and failure of the state in this regard is currently seen as one of the greatest threats to the security of individuals (International Commission on Intervention and State Sovereignty 2001).

It is in the context of this relationship between the state and its citizens that the issue of space has begun to appear. The state possesses the resources to exploit space, and the manner in which it is exploited can threaten other states and their citizens. Only the state, either alone or in conjunction with other states in the international community, can respond to such threats in order to provide security for its citizens. In so doing, governments must first recognize and understand the threats which emanate from the exploitation of space.

For a variety of reasons related to the manner in which space has been exploited and understood since the first satellite was launched in 1957, space has resided largely on the public margins of threats or national security concerns, even though the primary driver behind the exploitation of space has been defence related. In the case of Canada, space remains on the margins, notwithstanding the fundamental role played by National Defence (DND) in the initial years of the Canadian space program, the longstanding goal of Canadian foreign policy to seek an international treaty banning the weaponization of space, and the formal identification of space as a security issue by the DND and the CSA since the end of the Cold War.

That space remains on the margins of Canadian national security concerns and investment is not surprising. As a function of geography, the bilateral security relationship with the United States, ideas of Canadian exceptionalism, and the wealth and stability of Canadian society, national security has rarely been a salient political issue for Canadian governments. It was only in the wake of 9/11 that the Canadian government established a national security department titled Public Safety and Emergency Preparedness Canada (PSEPC), a federal cabinet committee on national security, and subsequently, in April 2004, a formal national security policy for the nation, one which largely ignored space (Privy Council Office 2004).

For most Canadians, space is figuratively out of sight and out of mind. Few Canadians recognize and understand the defensive and economic significance of space as discussed in the third and fourth chapters of this report. Successive governments have done relatively little to educate the public on the growing significance of space for the security of the nation. Instead, the manner in which space is exploited has been portrayed in relatively benign terms evident in the commercial and exploratory thrust of Canadian space policy. Yet outer space is a domain from, or through, which states can directly threaten Canada and override the security traditionally provided by the three oceans that surround us. It is also the home of a range of satellite capabilities or services which are vital to Canada's sovereignty, economy, and national well-being.

Arguably, the manner in which space has been exploited to date does not warrant its treatment as a primary threat to Canadian national security, notwithstanding the reality that long-range ballistic missiles transiting through space have been the major means by which an adversary such as the Soviet Union could strike Canada during the Cold War. No weapons are currently deployed on orbit that could attack Canada (or any nation, for that matter) with almost no notice. Also, no nation currently possesses the capability to systematically disrupt or destroy space assets or capabilities vital to the national or global economy.

However, space must be recognized and understood as a growing national security issue. As the technology to exploit space continues to develop and diffuse and as satellite capabilities grow in military and economic significance, the threat posed from space will increase. Potential adversaries will be driven to develop capabilities to threaten satellites and the services they provide. Satellites are particularly vulnerable, not least of all because of their predictable flight paths, or orbits. Moreover, at some future time, space will become normalized in much the same way that the exploitation of air occurred. In the same manner that air became a national security issue, so too will space. Preparing for this future is essential in order to protect the safety and well-being of Canada and its people.

Canada's National Security Condition

Throughout most of the twentieth century and continuing until the present, Canada and Canadians have enjoyed an unsurpassed level of security from external threats. This level of security has fundamentally been a function of geography, as was most effectively summed up by Senator Dandurand's famous 1924 statement to the League of Nations wherein he noted that Canada is a "fireproof house far from inflammable materials" (Nossal 1989, 141). Surrounded by three oceans and sharing a continent with a benign, superpower neighbour, Canada has never faced any direct, concrete threat of invasion. Even during the Cold War and despite the shrinking of the world through modern transportation, information, and weapons' systems, a sense of natural security permeated Canadian society.

During the Cold War, Canada did contribute significantly to the defence and security of North America and of Europe, primarily through the North American Aerospace Defence Command (NORAD), in the former instance, and through the North Atlantic Treaty Organization (NATO) and the presence of Canadian Forces in Europe in the latter. Nonetheless, defence and security has rarely enjoyed a prominent profile in the country, nor have they played a significant role in federal elections. Instead, Canadians have traditionally been more concerned about economic and social questions. Defence has also been chronically under-funded when compared to most other nations in the world. The concept of national security was rarely heard in discussions and debates about Canadian domestic or foreign policy until 9/11. Instead, the idea of international peace and security permeated Canadian discussions and became a formal pillar of Canadian foreign policy in 1995 (Government of Canada 1995).

Perhaps most indicative of Canadian feelings about security is the gradual emergence of beliefs about Canadian exceptionalism. Ideas about Canada's unique role on the international stage as a bridge builder, facilitator, and peacekeeper, among other descriptive terms, reflected in many ways the belief that Canada did not face any major national security threat and thus had the luxury of using its defence resources to aid other countries. This is especially the case since the end of the Cold War. Canada is relatively unique in being able to choose how it will contribute to international peace and security while meeting its international security commitments. In the current Afghanistan case, the idea that defeating terrorism overseas increases Canada's national security has not resonated with the Canadian public as a whole (Granatstein 2007), partly because Canadians cannot conceive of Canada being the target of a hostile state (or non-state actor). Canadians believe that, at worst, Canada might become an inadvertent target owing to its location and its integrated economic relationship with the United States. This view is evident, for example, in Canada's response to 9/11; Canadians' principal concern was economic. Maintaining an open border with the United States allows us to continue to enjoy an integrated economic relationship with our southern neighbour, and it is exactly that relationship that could make Canada a target.

Alongside the external dimension, feelings of a high level of security are reinforced by Canada's internal situation. Canada is a wealthy, stable nation. It ranks among the top advanced economies of the world. It possesses a stable and legitimate political, economic, and social system. Historically, few Canadians have been disaffected to the extent that they pose an internal threat to the security of the nation. One would be hard pressed today to identify any internal

question or issue that would create feelings of national insecurity in Canada. Even Quebec separatism has not been delineated in security terms. The arrest in 2006 of home-grown terrorists was met with incredulity at least as much, if not more than, as a concern for national security.

In this environment of relative security, it is difficult for Canadian governments to speak or act in national security terms, or to spend for national security purposes except after the fact, as in the case of 9/11. Yet preparation and action in advance of any direct threat to the nation is not only cost effective, it is a significant factor in mitigating that very threat's nature and impact. This is the situation currently facing Canada with regard to outer space and the capabilities and services derived from the exploitation of space today. Space is not an operational national security threat to Canada right now. Rather, it is best understood as an existing and evolving national security issue or concern that needs to be recognized and understood.

Space as a National Security Concern

Only once in recent memory has the government clearly acted before the fact to prepare for a national security threat. The rollover of computer dates from 1999 to 2000, better known as Y2K, was viewed as just such a threat. In preparation for that event, the government established a new agency, the Office of Critical Infrastructure Planning and Emergency Preparedness (OCIPEP) within the primary government agent for national security, the DND, and then invested resources to mitigate that threat and prepared detailed contingency plans to respond to it, if need be. However, this is a rarity. Instead, most national security threats either appear relatively unexpectedly, or they are ambiguous and hotly debated, with no clear or obvious options and no specific date to prepare for.

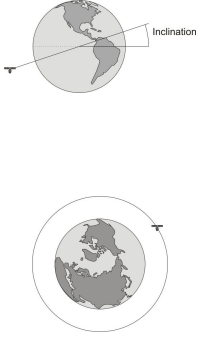
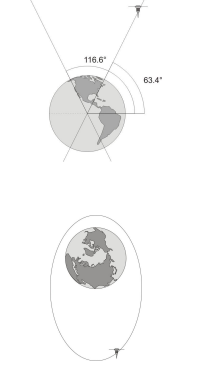
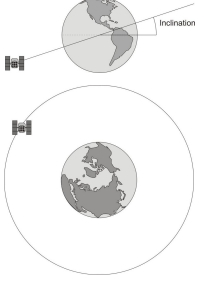
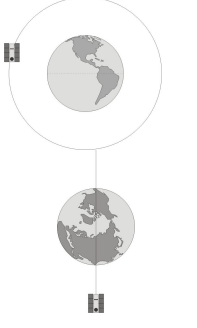
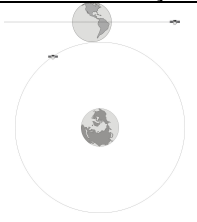
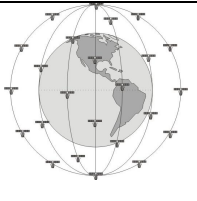
This is the current situation with respect to space. It is not Y2K, but it is a national security issue and a potential problem, as terrorism was prior to 9/11, and as a pandemic was prior to SARS. **No one can predict what event may suddenly elevate space into the ranks of an operational threat to national security. However, it is highly likely that such an event will occur, thus it is essential that we recognize that likelihood and assign resources in order to prepare for it and thereby minimize, as much as possible, its negative effects.**

Three factors underpin the basic case for recognizing space as a national security concern. First, the unique attributes of space as a function of the earth's rotation and orbital dynamics makes activities anywhere in space of direct concern to every nation (fig. 1.1). Hundreds of satellites pass over Canada every day. Second, space is a location which provides a unique means to threaten any point on the planet, as well as to enhance the defence and security of the nation. Orbital dynamics make space a place from which a state can physically threaten and attack any place in Canada, thus obviating the natural security derived from geography. It is also a place that provides new capabilities for defending and securing Canada, including the surveillance and communications coverage of the entire country, especially the sixty per cent of Canada's land mass lying to the north.

Finally, space, or more accurately, the satellites employed to exploit space, have become a crucial element in the global and Canadian economy. The loss of space services would have significant implications for these economies. In this regard, space as a medium of the information revolution and of a modern, information-based society and economy is central to the future of Canada as a stable, wealthy nation.

One part of the problem facing Canada in recognizing space as a national security issue is that Canada is a relatively minor player. Its actual presence in space is comparatively small in terms of the number of Canadian commercial and public satellites. It currently possesses no dedicated defence satellite on orbit, although one (Sapphire) is planned for launch in the coming year. Canada also possesses no independent access or launch capability, instead relying primarily upon the United States. As such, Canada does not face the threat of a Pearl Harbor in space, as

suggested by the United States' Commission to Assess United States National Security Space Management and Organization (Andrews et al. 2001).

Table 1.1 Primary Space Orbits			
Low Earth Orbit (LEO)		Molniya Orbit	
	<ul style="list-style-type: none"> • Orbits with approximate altitudes of 200 km. to 2,000 km. Period (time for one orbit) varies with altitude. • This is where most manned spaceflight takes place (all but suborbital and lunar flights). 		<ul style="list-style-type: none"> • Highly elliptical orbits (perigee ~200 km., apogee ~40,000 km.), with an inclination of 63.4° or 116.6°, and an orbital period of about 12 hours. • Satellite appears to "hover" at apogee, providing good coverage for high latitudes. • A small constellation of well-spaced satellites can provide coverage to high latitudes that a GEO satellite cannot (Soviet/Russian Molniya communication satellites).
Intermediate or Medium Earth Orbit (MEO)		Polar Orbit	
	<ul style="list-style-type: none"> • Orbit between higher LEO limit (~2,000 km.) and GEO (~35,800 km.). • Navigation satellite constellations (GPS, Glonass, and Galileo) are found in MEO space. 		<ul style="list-style-type: none"> • Orbits with inclination at or approaching 90°. • A satellite in polar orbit will eventually pass over all points on Earth. • Often used for Earth observation (weather, mapping, reconnaissance) satellites. <p>(shown is a perfectly circular Polar Orbit)</p>
Geostationary Orbit (GEO)		Constellation	
	<ul style="list-style-type: none"> • A circular orbit at about 35,800 km. above the Earth's equator will give a satellite an orbital period of one day (resulting in the satellite "hovering" above a point on the equator). • Large, expensive communication satellites are placed here, as are some ELINT spy and early warning satellites 		<p>Except for GEO, continuous coverage requires "constellations" of multiple satellites spaced along the same orbit. Global coverage requires that multiple orbital planes be inhabited by such chains of satellites.</p>

The event that will bring space onto the national security agenda is likely to be similar to 9/11; the sudden disruption or destruction of some part of civil, commercial, or military space by an actor targeting the dominant space power (the United States) or dominant space user (the West). Although Canadian satellites are unlikely to be the target, a sudden loss of space capabilities will have ramifications for Canadians' safety and well-being; the two categories used by Public Safety Emergency Preparedness Canada (PSEPC) to define a national security threat.

Space and the Safety of Canadians

For nearly all Canadians, space resides in the realm of the beyond; only visible at night, taught in schools, and occasionally brought to mind by shuttle launches, walks in space, video from the International Space Station, and/or Hollywood. If one were to ask the citizenry about threats to the safety of the nation, few, if any, would mention, let alone consider, space. If pushed, Canadians are most likely to think of asteroids striking earth as a function of two movies and recent science reports in the media. Yet ballistic missiles carrying nuclear warheads comprise the major, direct, space-related threat to the safety of Canadians since the early 1960s.

For reasons dating back to the creation of the *Outer Space Treaty* (OST) in 1967 (Dept. of State 1967) and the strategic interests of the United States and the Soviet Union, ballistic missiles were excluded from the definition of space. Nonetheless, ballistic missiles are no different from rockets or launch vehicles, whether they carry warheads through space, or carry satellites, the space shuttle, and the components of the International Space Station (ISS) into space. To master missile technology is to master the ability to access space, threaten assets on orbit, and deploy assets on orbit to threaten terrestrial targets.

Mastering missile or rocket technology does not make a nation a threat to Canada. Rather, it provides the means to threaten Canada when, or if, the political conditions arise. During the Cold War, missiles became the primary direct physical threat to Canada and North America by virtue of their speed and short flight times (approximately 30–35 minutes from the Soviet Union to North America), as well as the lack of any effective defence. The Soviet Union was not going to invade, because geography made it impractical and unfeasible. But it could threaten, and if need be, destroy North American cities (a category that included Canada because of its position within the Western world and its location near, and integration with, the United States).

Today, the Soviet Union is gone and Russia is no longer an enemy, but it still possesses the same capability. Nor is China an enemy, even though it also possesses ballistic missiles capable of striking North America. China is an up and coming military space power that recently demonstrated its ability to destroy a satellite on orbit (Covault 2007). What the future holds for Canada and the West's relationship with either or both countries is difficult to predict. If either relationship evolves adversarially, the threat of attack through space (and in the future, from space) will not only be real, it will be the primary means through which Canada can be directly attacked.

Perhaps of even greater concern is the proliferation of ballistic missile technology (and nuclear weapons) to states that are at odds with, if not clear adversaries of, the West, for example, Iran and North Korea. Save some dramatic political shift, it is only a matter of time before both will be able to threaten North America and Canada. Further ballistic missile proliferation to other states is also simply a matter of time. When this occurs, they will also be able to threaten Canada and satellites on orbit.

In addition to ballistic missiles, more states (for example, India, Israel, and Japan) possess the capability to launch into space, and this number is likely to grow as technology continues to diffuse and as access costs decline. Every state that develops a launch capability simultaneously acquires the means to strike targets across the globe. Any state capable of launching a satellite into low earth orbit can guide a warhead halfway around the world.

Today, there are no dedicated weapons in space (defined with reference to an orbit rather than the point at which no air-breathing plane can fly). Stationing nuclear weapons and weapons of mass destruction is prohibited by the *Outer Space Treaty* (OST). However, any object circling the earth can theoretically de-orbit and use its speed as a kinetic-energy weapon against a city. Space is the ultimate realm of dual-use technology and dual-use platforms, and the range of purposes a national satellite might be used for dissect civil, commercial, and military sectors.

In the future, the possibility of a space-related threat will only grow. As satellites' size and weight decline further (small, micro, nano, and pico satellites have already been developed) and as propulsion technologies evolve, an ever-increasing number of states will be able to entertain the costs of a national launch capability. As the level of commercial exploitation increases (and reduced launch costs are an important component of that development), so too will the number of states that become first-order, space-faring nations.

In the distant future, revolutionary new propulsion technologies are likely to normalize space. One stage to orbit; easy, cost effective, on-orbit manoeuvres; and space planes exploiting the high speeds of sub-orbital space speak to a different national security environment for all states, including Canada. For the first time, Canada is likely to face an omnipresent threat to the safety of its citizens and society where geography is truly irrelevant.

All this will not make space a national security threat; capabilities are only a threat when intended as such. But it does place space clearly on the national security agenda demanding attention and preparation. It will be the medium (and in many ways, it has been since Sputnik in 1957) of one of the major threats to the safety of Canadians in the future.

However, these two pillars need to be augmented by a greater national effort, as well. This effort begins by recognizing that the nature of space and orbital dynamics places it clearly on the agenda of threats to the safety of Canadians. Protected by three oceans, the only feasible means by which nations can realistically threaten the safety of Canadians is by using the medium of air, or space. The fact that Canada has no means to defend against a space threat, notwithstanding the United States' strategic deterrent and missile defence forces, makes it even more attractive for adversaries.

Space and the Well-Being of Canadians

Consistent with the inattention paid to space and the safety of Canadians is our neglect of the importance of space to the well-being of Canadians and the nation. Indeed, it is a vital component. Space-derived services, as discussed in chapter 4, play a significant role in maintaining Canada's standard of living. These services have been key enablers in the process of globalization and in the emergence and evolution of advanced, information-based economies and societies. Canadian sovereignty and its territorial claims are reinforced by space-based services, especially communications, surveillance, and navigation.

Whereas the safety dimension of national security stems from objects (or weapons) located in, or transiting through, space to terrestrial or space-based targets, the well-being dimension concerns the functions or services that satellites perform for societies. Orbital dynamics enable societies to exploit space to overcome the inherent limitations stemming from the shape of the globe. For Canada, in particular, space solves some of its inherent problems of size and location relative to the curvature of the earth. Space is the ideal location to provide three primary services: communications, observation, and navigation.

Satellites provide the ability to communicate rapidly across the entire nation, particularly from the populated south to the north. Communications constituted Canada's first foray into space, the Alouette Satellite. They also provide the means for Canada to observe the entire nation, even though Canada does not possess a satellite constellation providing twenty-four-hour-a-day,

seven-day-a-week, wide-area coverage. The government does have access to a range of observation or surveillance satellites, whether civil or commercial, and of these, only one is directly Canadian in origin (Radarsat I), with a follow-up satellite (Radarsat II) expected to be launched shortly. Finally, the ability to navigate and establish territorial claims, especially in the North, has expanded greatly, owing largely to satellites. The international public service provided by the American Global Positioning System (GPS) enables government and the public to navigate the nation more easily and effectively.

From a Canadian sovereignty perspective, space provides the means to communicate with, observe, and navigate the entire nation. This is particularly significant today in light of growing fears regarding Canada's claims to the North as a function of global warming. Access to northern waters is currently growing. Many predict that relatively easy access is not too far off. This substantially increases the need to observe the activities of foreign nations, as well as Canadians. Acquiring and enhancing the ability to respond to foreign incursions, such as through the acquisition of a deep-water northern port and new Navy vessels or Coast-guard cutters, are of limited value if government has limited knowledge of who is up there, where they are, and what they are doing.

Space also provides others with these same abilities. Any state, organization, or individual can potentially use space to communicate, observe, and navigate anywhere around the globe. At the same time, the major space powers currently possess the ability to know more of what is going on in Canada owing to their space capabilities than Canada currently does. **Furthermore, the major space powers, amongst others, can use a variety a means to avoid detection in the absence of an all-weather (radar), constant, wide-area, space-based, national surveillance system.** In contrast, Canada largely relies either upon the United States, the major space power (or first-order, space-faring nation), or on commercial satellites to obtain significant amounts of space-derived information for a range of purposes, including national security and other sovereign purposes.

Alongside the growing sovereignty dimension, communications, observation, and navigation have also become increasingly indispensable to Canadians. Large amounts of virtual capital flow across space, connecting financial activities within the nation and with the global marketplace. Automated teller machines dependent on GPS atomic clocks enable citizens to do their banking at their convenience. Fishing fleets have become more efficient as a result of GPS. Agriculture and mining increasingly benefit from remote sensing capabilities. Understanding and monitoring environmental developments, especially with respect to the shrinking of Arctic ice, are greatly facilitated by remote sensing satellites.

In other words, Canadians have become increasingly dependent upon space for their well-being. As time goes on and new technologies emerge, this dependence will only grow. As dependence grows, so also do old ways and means disappear. Just as few Canadians today have any knowledge of the requirements of a transportation system reliant on animals, few future Canadians will know how to navigate without GPS.

It is difficult to estimate the economic contribution and impact of space, and existing estimates are largely intuitive rather than well grounded in economic data. It is difficult to measure and quantify a sector which simply provides information-based services. Besides information, space is not a domain where goods are manufactured, despite the suggestion of future possibilities for zero-gravity production. It is also not yet an environment easily accessed for tourism purposes. Space is a place where information is transmitted between points on the ground below, or where information is acquired about points on the ground below and sent back for analysis and use.

Even from an industrial perspective, where space begins and ends is arbitrary. Though they are generally collapsed within the aerospace sector, many of the technologies enabling the exploitation of space are drawn from outside that sector. Optical lenses, computer technologies, and transmitters, among other things, are part of other sectors of the economy.

When all these factors are put together, space services are a vital element of a modern and a global economy. In this sense, it is part of a nation's critical infrastructure, even if a nation like Canada possesses few assets or satellites of its own. Conservatively speaking, the loss of space could cost the Canadian economy tens of billions of dollars in lost productivity. Two prominent examples of the significance of losing space services exist. The first is the loss of the Galaxy 4 satellite in 1998 that shut down thousands of pagers, televisions, and gas station payment systems across North America. No one, however, has estimated its short-term economic and social costs. The second instance directly related to Canada is the loss of the ANIK satellite which turned off television signals. Again, the short-term costs were not estimated.

In addition, reconstituting space services if a large numbers of satellites were accidentally lost or purposely rendered inoperable or destroyed would also be problematic. These would take some time to replace, because spares are not readily available due to costs (which could even affect nationally dedicated military/national security satellites) and to the currently marginal profit lines for the commercial sector. If a nuclear weapon were detonated, part of space would be rendered inoperable for some time to come except to well-hardened satellites, which are normally exclusive to the military.

Of course, space in this context may take a different direction as access becomes easier and as ever more states acquire a stake in space. This may lead to the eventual development of a multilateral treaty banning weapons in space, a longstanding Canadian goal. Even so, such a treaty would not negate the threat posed by the transit of ballistic missiles through space to terrestrial targets. In this regard, the bilateral defence relationship will continue to be vital to this strategy in terms of reliance upon the American nuclear deterrent and the American ballistic missile defence capability for North America, regardless of Canadian participation.

It is hard to imagine space as being crowded, but the nature of orbits (along with debris, both natural and man-made) increases the possibility of accidents. Like air before it, the need to develop rules to govern space is growing, and the current international regime is highly limited. Attention needs to be paid to this future, because the way the regime plays out will be of significance to Canada and the well-being of Canadians.

One significant example for future national security consideration is the area between air (considered sovereign territory in international law) and space (considered international territory). Air is generally seen to end at the altitude of 50 kilometres, the delineation beyond which air-breathing planes cannot operate. Space currently begins at an altitude of approximately 150 kilometres, which is where an object can complete a single orbit. Between these two key points is 100 kilometres of no-man's land. As this sub-orbital area comes to be exploited with future technologies, key sovereignty (and thus national security) concerns emerge about how the community responds. Like the dispute over the status of the Northwest Passage in international law, the future of this no-man's land is important to Canada.

Finally, relative to the well-being of Canadians, space also raises issues of Canadian engagement and investment, today and in the future. The explosion of activities in space will open up dramatic new economic and social opportunities, of which tourism is the most prominent in current thinking. Space technologies, capabilities, and investments are likely to become even more significant in the generation of national wealth in the future. If Canada adopts a wait and see posture, economic opportunities will likely be lost. Careful planning and investment is needed today, along with a vision of the future from a national security perspective. Understanding relative to the well-being of Canadians goes beyond recognizing space as vital to a modern economy and standard of living that can or will be threatened. It also includes the need to engage in the exploitation of space to reap potential benefits to protect the future well-being of Canadians.

A hundred years ago, the airplane and the exploitation of air were in their infancy. Beyond science fiction enthusiasts like H.G. Wells, few could imagine how the airplane would transform the world. Today, the aerospace industry is worth hundreds of billions of dollars, directly or

indirectly employs hundreds of thousands of people, and is indispensable for every type of military operation. Air is all about national security.

Space now stands on the cusp just as air exploration did roughly eighty years ago. Tomorrow, space may well rival air in the aerospace equation. Physics (the speed of objects in the vacuum of space) married to new technologies will enable people and cargo to transit half-way around the world in less time than it currently takes to fly from Vancouver to Montreal. Traveling to space may become as normal as traveling between terrestrial points. Space tourism into low earth orbit will become available to more than just the wealthy. Research, development, and production facilities will exist on orbit, exploiting the value of zero gravity.

National militaries and internationally sanctioned military operations are also increasingly dependent upon space. In this regard, space will likely become its own strategic environment with its own dedicated military service and components. The possibility of war in space will become a major strategic issue. National reach and global power projection will be available to many states.

As all of the above occur, a range of new issues and disputes will emerge, including the definition of space itself from a national sovereignty perspective. New international agreements and institutions will be needed to manage and regulate civil, commercial, and military space. Space by then will be on everyone's national security agenda in terms of the safety and well-being of people everywhere.

Conclusion and Recommendations

Space itself and the services it provides are growing national security concerns for nations. Except for the major first-order, space-faring powers that possess the full range of space exploitation capabilities which have always been driven by national security considerations, most nations have tended to ignore or downplay the security dimension. In Canada's case, space has resided largely on the margins of national security issues, in part because national security has not been a major public and political concern given our relative geographical isolation.

Whether from the perspective of Canadian's safety or of their well-being, space and satellite services are directly relevant to Canada's national security. The government and the agencies responsible for national security and outer space in Canada need to recognize and understand existing and future security issues related to the exploitation of space.

Recommendations include:

- **The Government of Canada should recognize that outer space and the services derived from satellites constitute a growing national security issue affecting the safety and well-being of Canadians; and**
- **National security should be a central focus of any review of Canadian national space policy and strategy.**

CHAPTER 2

CANADA, NATIONAL SECURITY AND SPACE TECHNOLOGY

Introduction

The national security importance of space rests on the technologies that allow states to exploit space for a range of interests. At its core are the technologies that enable states to access space. Without them, space would have no bearing or relevance. With the ability to access space now in place, **we use it for two primary purposes; to provide space-based or satellite services to earthly or terrestrial users (for example, communications, remote sensing, and navigation), and to explore space for purposes of scientific understanding and discovery.** Space access, utilization, and exploration are complementary and interdependent. However, they also compete for scarce investment dollars. Appreciating the technological trends of all three illuminates past, present, and future space developments, especially as they relate to national security considerations. They also provide the means to understand the evolution of Canadian space activity in the context of global developments, as well as the challenges and opportunities that confront a nation such as Canada.

Canada's interest in space dates back to the 1930s. However, true substantive space investment did not start until the 1950s and can be most easily appreciated in terms of three periods that reflect those access, utilization, and exploration dimensions. The first, roughly from 1955 to 1970, corresponded with Canada's major, though not exclusive, focus on access to space through the development of rockets and satellites. In that period, Canada developed the Black Brant and its first satellite, Alouette I. The Black Brant, a sub-orbital vehicle, is still in production today, while Alouette I initiated a sequence of satellite developments that carried the country through to its second space period.

During this second period, roughly from the early 1970s into the 1980s, Canada's space interests and investments shifted from space access to space utilization. The country gave up its interest in developing and building rockets, and concentrated on furthering the end-use aspects of space-based systems, on the assumption that access could be readily garnered elsewhere (primarily from the United States). Canada focused on developing commercial, space-based communications and later, remote sensing satellite services; Telesat Canada was created, a series of communication satellites was launched, and Radarsat 1 was developed.

Preceded and foreshadowed by Canada's Canadarm contribution to the American shuttle program and the establishment of an astronaut program, the third period commences around the late 1980s, coinciding with the creation of the CSA. This period continues to the current era, when national goals and investment once again shifted somewhat. Utilization gave way to a drive towards space exploration: from using space for earthly purposes to exploring space for enhanced scientific understanding. This latest and ongoing period has been largely captured by Canada's involvement in the United States-led International Space Station (ISS) and by recent indications of a Canadian or CSA interest in participating in the proposed American-led return to the Moon.

Despite this shift towards space exploration, Canada maintains a deep dependency on space-based communications, navigation, and remote sensing services (space utilization). Space is a natural ally for Canada with respect to overcoming its huge landmass and its dispersed and relatively small population with the attendant national security connotations. Similarly, Canada's relative movement away from space access and fundamental satellite technologies means the country is increasingly reliant on others for core space technologies. This development has security implications in terms of relying on others for access, which of course predates the shift and Canada's ability to invest its limited space dollars for purposes of national security.

Today, ardent space advocates champion Moon and Mars explorations, and closer to home, space tourism. Yet there has been an immense expansion of both space access alternatives and

space-based information services over the last fifteen years, and these will continue to grow over the coming fifteen years and beyond. Canada is more dependent upon (and conversely, vulnerable to) these developments, and will become even more so. If the patterns of the last fifteen years of national space investment persist, Canada will have little participation in, influence on, or control over these developments.

Canada and Space Access Trends

Space access precedes and permits all space interests and endeavours. Indeed, the original definition of a space-faring nation required an access or launch capability (Lambakis 2001, 45). Moreover, the significance of a launch capability would be enshrined in the 1972 *Liability Convention*, whereby the launching state is liable for damages caused by satellites (app. A). The launch requirement is no longer part of the common definition of a space-faring nation, but it is important to differentiate between states which possess the full range of space capabilities (of which independent access is key) and those which lack that access: these are classified as first-order and second-order space-faring nations respectively. Second-order space-faring nations like Canada are dependent upon other states or commercial entities for access. This has significant implications for their ability to participate in, and influence developments related to, the employment of space for whatever security, commercial, or scientific purposes may arise.

Before a state can utilize space, it must have access, and understanding access begins with the problem of defining outer space. Even though space is international, as defined in the OST, there is no universally accepted definition of where space starts or, for that matter, where it ends. Unlike the planet's three other environments – land, sea, and air – there are no clear discerning boundaries defining space.

Nonetheless, it is the domain or region immediately adjacent to the planet's thin atmosphere and biosphere of life and extends infinitely beyond. Space lies immediately above every region of the planet, and much of its value and its security significance rest upon this fact. Space commences where aerodynamic flight ceases to be possible, about 50 kilometres above sea level. Yet in interpreting the provisions of the OST, space legally begins at an altitude of roughly 150 kilometres, where an object (satellite) is able to complete an orbit. This leaves a 100 kilometre “no man's land” that legally has neither international nor national status.

Space is also a difficult environment to access and a harsh environment within which to operate. A spacecraft must function in a relative vacuum where there are high temperature variations as well as high radiation and particulate levels. More importantly, it is the realm of ultra-high speed. Above 50 kilometres, ultra-high speeds can be progressively obtained using super (Mach 1–5) to hypersonic (Mach 5–20) sub-orbital vehicles, currently represented by ballistic missiles. Realistic earth orbits occur at speeds in the realm of Mach 25. Interplanetary travel and beyond demands and allows for speeds well in excess of Mach 25.

Before one can consider what to do or where to explore in space, one must first have the ability to access space and remain there, and that demands immense energy. While rockets look deceptively simple, rocket science has achieved its reputation of immense complexity for good reason. Space access rests at the frontier of energy, material, and information science and technology. Rocketry is also an area currently awaiting revolutionary advancements in the areas of propulsion and/or material technology which would drive space access costs down to levels comparable, for example, to the cost of moving people and goods by air. Such advancements would essentially “normalize” space as a commercial, military, and scientific venue, with the attendant security issues that would naturally arise.

Extrapolating from the rate of reductions in access costs that have occurred in the past decade, further evolutionary change can be expected over the next twenty years. In terms of rocketry or access vehicles, evolutionary development is currently centered upon the expendable launch vehicle, or ELV, that can place a light-to-heavy payload into low-to-high earth

orbits. This vehicle is poised to be joined over the next two decades by two new designs: the partially-to-fully reusable, light, sub-to-low earth orbit vehicle, and the very heavy, human-rated, expendable lunar and interplanetary space vehicle.



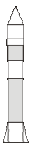
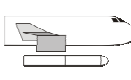

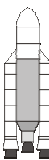


Rocket development during the first thirty-odd years concentrated largely on the development of larger-sized vehicles that could carry heavier payloads to higher orbits. The well-known Delta, Atlas, and Ariane vehicles emerged within that time-frame. During this period, the space shuttle, and the Soviet Union's attempt to develop a similar vehicle, was an anomaly with its semi-reusable design and lower orbit limit, though it was carried into orbit by a heavy rocket launcher.

The space launch industry during these years was both trapped by, and content with, Cold War political constraints, heavy cumbersome satellites, and a design philosophy based on the premise that the more you could launch, the cheaper the cost per kilogram would be. In particular, the high costs associated with heavy launch, alongside the Cold War constraints and the absence of a commercially viable market, significantly informed decisions by countries like Canada to forego an independent launch capability. Today, however, not only are the Cold War constraints long gone, but the historic design philosophy has been rethought as a result of evolving micro-electronic, computing, and electrical power technologies which are steadily reducing satellite weight requirements. Under continuous pressure to reduce cost-to-orbit and increase responsiveness and reliability, the industry has developed over the last decade a much broader spectrum of vehicles of assorted sizes. In so doing, it also became significantly more competitive. The average commercial launch price dropped from C\$100–C\$120 million in the 1990s to roughly C\$60–C\$75 million today (ISBC 2005, 35).

Reflecting this new, more competitive market, all of the launch vehicle types available at the start of the 1990s have undergone measurable performance and cost improvements. In the United States, Boeing and Lockheed Martin introduced their respective families of Evolved Expendable Launch Vehicles (EELVs), Delta IV and Atlas V, while the European Space Agency (ESA) added Vega and Soyuz to its launch options. Over the last fifteen years, both the improvements on previous models and the innovative new designs have measurably advanced expendable launch costs and reliability and have expanded launch options. Today, one can choose to place multiple satellites in one large launcher, or alternatively, consider using multiple smaller ones. Nonetheless, it can still cost upwards of \$25,000 per kilogram to place a payload in geosynchronous orbit, which is usually one-third of a space project's up-front costs (see table 2.1). Given that level of expense and the appearance of new commercial launch entities like SpaceX (Covault 2004), the search for new technologies to drive down launch costs remains a priority, especially in the United States.

The United States Department of Defense (more specifically, the United States Air Force) continues to seek a more economical and responsive way to access low-earth-orbit (LEO) and near, or sub-orbital, space (the latter area was hitherto generally home only to ballistic missiles and their payloads (warheads) in transit [Piscopo 2004]). The goals of the United States are to lower access costs by a factor of ten, and increase access reliability by at least the same rate – from one failure in a hundred, to one in a thousand launches. This has been the goal for over a decade (Futron 2002). Some \$10 billion dollars has been expended since 1991 in research and development projects such as the National Aerospace Plane (NASP), the X-33/VentureStar, and more recently, the Defense Advanced Research Agency's (DARPA) Falcon Program (Tajmar 2003). While the first two did not meet expectations, and have fallen by the wayside in some respects, the Falcon project, which reflects America's continuing pursuit of easier, cheaper, and more reliable access, is proceeding.

The multi-faceted Falcon Program includes the development of a new generation of small launch vehicles (SLV) that can rapidly place small satellites into LEO, and thus provide a reliable and responsive reconstitution capability for the United States (table 2.1). The project, which began in 2003, and is scheduled to conclude in 2010, currently focuses on being able to place a 400 kilogram satellite into a 150 kilometre orbit for less than C\$6 million. Similar to the Pegasus launch

Table 2.1 Select Launch Vehicles and Payload Costs	
Black Brant (Canada, 1961)	
	LEO Payload: N/A GEO Payload: N/A Suborbital Payload: 850 kg.
Soyuz 11A514 (USSR, 1968)	
	LEO Payload: 7,000 kg. Cost: C\$5,900/kg. GEO Payload: 1,350 kg. Cost: C\$30,000/kg.
Atlas 2AS (USA, 1993)	
	LEO Payload: 8,618 kg. Cost: C\$12,000/kg. GEO Payload: 3,719 kg. Cost: C\$29,000/kg.
Pegasus XL (USA, 1994)	
	LEO Payload: 443 kg. Cost: C\$34,000/kg. GEO Payload: N/A Cost: N/A
Long March 3B / CZ-3B (China, 1996)	
	LEO Payload: 18,000 kg. Cost: C\$10,000/kg. GEO Payload: 5,200 kg. Cost: C\$13,000/kg.
Ariane V (France/ESA, 1996)	
	LEO Payload: 18,000 kg. Cost: C\$10,000/kg. GEO Payload: 6,800 kg. Cost: C\$27,000/kg.
Delta IV Heavy (USA, 2001)	
	LEO Payload: 25,800 kg. Cost: C\$11,000/kg. GEO Payload: 10,843 kg. Cost: C\$26,000/kg.
Falcon IX (USA, Future)	
	LEO Payload: 9,900 kg. Cost: C\$3,540/kg GEO Payload: 5,070 kg. Cost: C\$11,000/kg.

capability now in operation, its advantage is the reduction of costs produced by minimizing internal rocket propellant, and lowering traditional ground and safety requirements by employing an aircraft like the C-17 military cargo plane as the launch platform. It would carry the rocket and its payload to the optimal launch latitude, probably over open ocean (Ball 2005).

Falcon, however, is not limited to exploring SLV technologies. It also includes sub-orbital Hypersonic Cruise Vehicle (HCV) concepts and technologies (DARPA 2007). In so doing, Falcon, alongside other developmental programs, promises to open up the sub-orbital region to exploitation beyond ballistic missile transit.

Sub-orbital space was the first region that could be accessed once ballistic missiles were developed, beginning with Germany's WWII, V2 rocket. It is the region of the upper reaches of the atmosphere, between roughly 50 and 150 kilometres, where orbital speeds (Mach 25 and above) cannot be easily sustained because of the high drag and heat created by a lingering atmosphere. It takes roughly ten times the energy and cost to operate in sub-orbital space than it does in the earth's atmosphere. However, one can travel ten times faster, thereby travelling half-way around the planet within one hour, if desired. With such speeds, the ability to exploit sub-orbital space would open up an entire range of new military and commercial possibilities (Tajmar 2003).

The development of RLVs employing new lifting body technologies (potentially including a hybrid, scramjet propulsion system that could adapt to the low oxygen content of the upper atmosphere), is critical to exploiting sub-orbital space. The development of RLVs for sub-orbital purposes is arguably imminent for both military and commercial users (transportation and tourism), with low earth orbit RLVs further out on the time horizon. Recent indicators of this future include scramjet demonstrations by the United States and the Russians, as well as the recent Ansari X-Prize flight of SpaceShipOne in 2004 (Scaled

Composites 2004). Regardless, the future will likely be driven by the USAF's National Aerospace Initiative (NAI 2004), and current excitement about, and commitment to, space tourism by such notables as UK-based Virgin Galactic (Malik 2006).

Further out on the time horizon, but visible and increasingly assured, is the return of a human-rated lunar and interplanetary vehicle capability and industry; a capability not seen since the days of the United States Apollo Program and the development of the Saturn V rocket during the 1960s. A 2004 United States presidential initiative to return to the Moon as a stepping-stone to exploration deeper into the solar system has already generated much engineering activity and a host of decisions by NASA, the initiative's lead department and champion. Again, led by the United States but fuelled this time by a low-level rivalry with China, the Constellation Program envisions the retirement of the American Shuttle by 2010, and the development by 2014 of the Aries launch vehicle and the Orion crew exploration vehicle, as well as the implementation of a Commercial Orbital Transportation Service (COTS) to service the ISS. This will all be followed by a return to the Moon by 2020 (NASA 2006).

By 2020, the world of space access will look appreciably different than it does now. Joining today's ranks of space launch vehicles (some sixty types and variations) will likely be an assortment of publicly and privately funded, small sub- and low-earth orbital vehicles, and at least one large-scale, lunar/interplanetary, human-rated system. Driven by industrial competition as well as the more traditional competition between nations and fuelled by new technologies and revenue sources, the new access systems will enjoy greater reliability and responsiveness at lower costs, notwithstanding a revolutionary development that could radically alter the entire world of access.

As a result, space access will become more ubiquitous. The world of space access has expanded from the two superpowers to include the European Space Agency (ESA) led by France, China, Japan, Russia, India, and Israel. These are set to be joined by new commercial capabilities and new launch-capable states as a function of the proliferation of ballistic missiles and associated technologies. This is not to suggest that proliferators, as well as the aforementioned pre-existing, launch-capable states and commercial entities, will be able to operate launches on a profitable or a cost-recovery basis in the absence of government support or subsidization. For the foreseeable future, the marketplace is likely to remain highly competitive, and it will privilege launch over capacity. However, the costs to subsidize a national capability have already decreased, and they are expected to continue to decrease, thus making states more willing and able to bear the financial burden. The incentive to do so is also increasing, for reasons of both national prestige and security (including the significance of states having influence over the manner in which the domain of space is exploited and regulated).

Of course, the launch or access side of the equation cannot be separated from the utilization side. More cost-effective launch options provide a range of new opportunities for other states to acquire their own national satellite capabilities, as evident in the recent launch of Nigeria's first satellite that was built and launched by China. China's reasons for assisting Nigeria were not just commercial; they also stemmed from the fact that Nigeria is a major oil exporting nation. Regardless, more states able to access space, independently or not, raises a host of security concerns including, *inter alia*, launch notification, orbital locations, frequency allocation, debris mitigation, and a host of military concerns as a function of the inherent dual-use nature of satellites, as discussed in chapter 3.

Even though space as a place cannot be appropriated or owned (and unlike its air counterpart, space is an international domain in international law), space in many ways has been owned or governed in the past by a select few; those who have been able and willing to afford the development and operation of a space launch and access capability. The international regime governing space was largely a product of the interests of the two original first-order, space-faring nations, the United States and the Soviet Union. It follows that future legal and regulatory developments, including the treatment of sub-orbital space, are also likely to be dominated by

first-order states, including those that are home to commercial launch entities. States like Canada that do not have independent access may have little choice but to sit on the margins, hoping to influence the outcomes as much as possible.

Due to early decisions not to pursue space access, not least of all because of high costs and limited national demand, Canada implicitly chose not to be a central player in the domain's legal and regulatory development or management, despite the best efforts of Foreign (then External) Affairs to promote a deepening and broadening of the legal regime. To date, this decision has been relatively benign with respect to consequences. However, the growing nature of access outside Canada raises concerns, especially in relation to sub-orbital space. Notwithstanding the ongoing process of ballistic missile proliferation (old access technology), high-speed, manoeuvrable space planes will open up the no-man's land of sub-orbital space for military and commercial applications, as well as a host of regulatory issues and legal questions. The results or outcomes are likely to affect Canadian national security simply because space resides above Canada, as it does the entire globe.

This may not prove problematic. At the end of the day, Canada's national security interests may not diverge greatly from others', especially the United States, with which it shares this continent. But if Canada's interests do diverge, as evident, for example, on the legal status of the Northwest Passage and over an international treaty prohibiting the weaponization of space, then Canada will likely have to accept an outcome(s) at odds with its interests because of the lack of an independent access capability and the influence that obtains on the international stage.

This need not be the case, however. As noted above, **the access world has changed significantly since the decision was made in Canada to forego a national launch capability. The political, technological, and cost calculations now open up the possibility to acquire such a capability at reasonable cost, even though it will continue to require subsidization.** For example, a recent study posited a micro-satellite launch capability well within Canada's reach using the Pegasus model at an estimated cost of C\$130 million for development of a launch vehicle and ground infrastructure, resulting in an estimated launch cost of \$3 million per satellite, not including satellite-related costs (Defence Science Advisory Board 2005). Moreover, the growing security implications of space for Canada creates the demand for a national capability, just as air demanded one in the twentieth century.

Canada and Space Utilization Trends

While space access is a necessary means, space utilization for earthly purposes has been, and will continue to be, the overwhelming payoff for public and private space investment. Earth's circumjacent space enjoys two key attributes for earthly exploitation: global observation and rapid global reach. First, space provides an unparalleled perch from which to observe earthly happenings and to communicate using satellites. It is often referred to as the ultimate high ground in military circles. Second, as a domain, space permits unparalleled transit speeds, thus far only exploited for military, ballistic-missile purposes. These two attributes will continue to draw further investment in the years to come.

While the information age has lost much of its luster over the last half-decade, humanity has an insatiable appetite for information and communication. Much of the commentary about the information age has focused on the role of the microchip and the computer. Little appreciation exists of the role space has played, and will continue to play. Information demand has been good for space development, and space development has been good for information demand. Between 1995 and 2004, 1,060 satellites, (with life expectancies ranging from one to fifteen years) were launched into earth orbit (Teal Group Corporation 2006). This is two satellites per week, on average. Today, some 700 active satellites are fulfilling a host of information functions for a growing, global community of users.

As the ultimate high ground, its worth or value derives from facilitating global communications, navigation, and earth- or remote-sensing services. The planet's orbital space is humanity's information space. It is progressively getting busier, with access interests moving progressively from GEO inwards towards LEO. It contains a range of traffic from single satellites to integrated constellations such as the Global Positioning System (GPS).

Military interests and activity in earth's orbits precipitated initial development. Military interests continue to fund and lead space-based information technology developments. In this age of information and the so-called revolution in military affairs (RMA), space has taken on a level of significance not seen before, particularly with American military planners. Space-based information services are a feature of current American debates on information warfare, ballistic missile defence, joint operations, and transformational thinking (Mowthorpe 2005). In the future, United States military planners envision that satellite remote sensing, positioning, and communications services will dramatically increase their forces' spatial and temporal battlespace awareness.

While led by the United States, military interest in the future uses of space includes many other countries as well. Around the world, including within Canada's military, there is heightened interest regarding the use of space for the acquisition and dissemination of battlespace information. While greatly tempered in comparison with American programs, space is recognized within NATO membership and elsewhere specifically for its communication and surveillance advantages (Euroconsult 2005, 11). Over the next fifteen years, militaries led by the United States will see the emergence of fourth generation communications, navigation, and remote sensing systems. These systems will have greater ubiquitous, all-weather, and real-time characteristics. They will also enjoy a far greater level of inter- and intra-system integration and data fusion.

Supported by an ever-expanding and deepening global, geo-spatial database, the next fifteen years will also witness the emergence of systems where remote sensing data from discrete satellites and within constellations will be fused with precise navigation and timing information and compared in real-time to a constantly updated, global, geo-spatial database in order to detect changes below. The constant flow of information will be disseminated via satellite communications at the speed of light to military and civilian end-users around the world (table 2.2).

Table 2.2 2004 Satellite Launches, by Operator (Teal Group Corporation 2006)		
Satellite Operator	Satellites Launched	Annual %
Civil Space Agency	28	38
University	2	3
Military	23	32
Commercial	20	27

Alongside military interests, civil science and commercial interests have also become dependent on space-based services. Like the military, their dependence on these services will continue to grow, as will the development of supporting technologies. In terms of earth sciences, space-based remote sensing information is unmatched in weather observation and forecasting and in global warming and environmental degradation research. This information will increasingly be called upon for disaster warning and

response, in addition to resource exploration and monitoring (Morrison 2005). Currently unfolding hyper-spectral, electro-optical, and radar processing technologies will fuel growth, as will advanced change-recognition and data-fusion capabilities.

Space-based navigation and precision timing services will also increasingly be called upon by both civil and commercial users. In the coming decade, the next generation of American Navstar GPS and Russian Glonass systems will appear, as will Europe's Galileo constellation (Taverna 2006a). Other nations, such as China and Japan, are also developing navigation satellites, at least to augment existing and planned constellations for national purposes. The management of land, sea, and air transportation will likely become exclusively dependent on space-based navigation, as will land surveying and exploration worldwide (Mathews 2006).

Alongside our growing dependence on navigation services is the world's reliance on space-based, precision timing, currently provided by GPS. Space-borne precision global timing services are currently used by the world's banking and investment community for tracking financial transactions. Like other services, space-borne timing dependence will only increase as the world becomes increasingly integrated in a host of online services through the internet.

Online Google Earth and General Motor's "Onstar" roadside service are, for example, both space services. They foreshadow a quantum increase in individual wants and expectations from space-based sensing, navigation, and timing systems. These systems (and others as they emerge) will rely even more upon the earliest and most mature space-based service: communications.

Over the coming decades, the world will increasingly enjoy more advanced services from the already well-established commercial satellite communications industry. These systems date back to the earliest days of space flight with the creation of Comsat in the United States and the orbiting of the first Telestar satellite in 1962. Early on, satellite communication services were largely limited to providing bent-pipe, long distance communications between corporate clients, primarily telephone companies. Today, satellite communications comprise a host of services including fixed, point-to-point, narrow and broadband transmission, mobile communications to both commercial and individual users, and a growing spectrum of direct-to-home and direct-to-business broadcast services. Satellite radio is but the newest entrant.

Currently, the satellite communications industry has some 250 satellites in GEO, as well as over 100 satellites in LEO constellations. Through the 1990s, the industry sought to establish profitable constellations, such as Motorola's Iridium system and Globalstar. However, both were technologically and financially overtaken by the emergence of the digital cellphone industry. While this damaged the industry in the short term, it also gave birth to new hybrid terrestrial/satellite broadband mobile communication concepts employing low-priced, cellphone-sized handsets with competitive user fees (Taverna 2006b).

Today, the commercial communications satellite industry is fully integrated into the global communications architecture. It will witness further growth and development through the coming years as new technologies are developed in areas such as data compression, bandwidth utilization, laser transmission, and on-orbit power generation. Although it suffered from the 1990s setbacks, the robust, large-scale, and cross-linked satellite constellation remains a promising concept, especially when linked to declining launch costs. Able to exploit an endless supply of solar energy and the future arrival of on-orbit robotic refuelling and repair vehicles (Dornheim 2006), large-scale communication constellations in the future will provide real-time broadband global communications coverage through a host of small, handheld multimedia devices.

Competitive pressures and further investment in the field of satellite design and manufacturing (table 2.3) will continue to improve the capabilities and cost characteristics of every kilogram placed in orbit. Technological developments in power and computer systems have noticeably impacted satellite design concepts and capabilities over the last fifteen years. This process will continue in the future as technologies such as smart-skins, multi-functional structures, laser optics, and nano-servo devices are all exploited for space purposes. Perhaps more importantly, ongoing improvements in solar array technologies will further facilitate the utilization of space.

Over the last decade alone, the generation capacity of satellite power has doubled. Telesat Canada's Anik E satellites, with four kilowatts of power, were launched fifteen years ago amid much fanfare. The Aniks are dwarfed by today's systems. Solar power systems in the twenty kilowatt range are a reality. In the coming decade, these systems will grow substantially and increase a satellite's performance, particularly in the business of satellite communications, where transmission capacity is tightly bound to power availability.

A spacecraft's utility is also strongly linked to the level of computing power available. Satellites and computers are natural partners; a satellite provides the platform from which an immense amount of data can be collected and distributed, while the computer sends, receives, and makes sense of the data. Historically, space activities were constrained by limited on-board and end-user processing capabilities. Today, ongoing capability growth in both processing and data movement are making once unrealistic military, civil, and commercial space ventures viable and highly desirable (Scott 2006). These include the use of very large scale satellites, as well as very small nano or pico size instruments. Current trends in satellite and information technologies will substantially increase a satellite's per-kilogram performance in the future, while simultaneously reducing its costs.

Beyond increased ground utilization interests, over the next twenty years (as intimated in the discussion on access), hypersonic global transport (Mach 5–20) through sub-orbital space will likely become a reality. As noted above, space as a medium permits unparalleled transit speeds, thus far only exploited by militaries for ballistic missile purposes. The aforementioned sub-orbital hybrid scramjet, lifting body, and thermal technologies currently under development will create a new dimension of space utilization discussion around 2025; the movement of people and goods through space to terrestrial points. While one should be cautious when predicting precise dates, a military space plane and civil side space-liner (akin to the arrival of Concorde flights in the 1970s) will emerge, along with space tourism. Not surprisingly, their emergence will rest largely upon American initiatives and investments over the coming two decades.

Canada devoted significant resources to developing space utilization hardware and capabilities through the 1970s. Emphasis was placed on expanding Canada's commercial space communications capability. Later on, through the 1980s and into the early 1990s, Canada implemented space-borne radar (Radarsat 1) for environmental monitoring purposes (with Northern Canada as the prominent focus). Canada also reached a number of impressive milestones over that period. The first national communications satellite system became operational in 1972, and the first direct broadcast satellite followed in 1976. Canada also received considerable international recognition, first in communications innovations, and later in the field of remote sensing. However, as the space utilization world took a major leap forward following the first Gulf War (1991), Canada's focus largely shifted towards space exploration. Canada continued to pursue new space technologies and applications like MSat, and Radarsats II (currently awaiting launch), but the Canadian government's interest and involvement declined sharply.

Apportioning resources to space applications in the early 1990s declined with the government's primary goal of reducing the national deficit, and in light of its previous commitment to participate in the United States'-led International Space Station (ISS). Regardless, Canada today finds itself relatively weaker in space utilization wherewithal than it was fifteen years ago.

As Canada has been stepping back from national investment in space utilization initiatives, the rest of the world has been increasing their resources and their commitment to these projects. Civil space budgets outside of NASA have been increasingly focused on communication, observation, meteorology, and navigation developments: 44 per cent in 2004 as

Table 2.3
Satellite Subsystems
(Larson and Wertz 1991, 287)

Subsystem	Function
Propulsion	Provides thrust to adjust orbit and attitude
Power	Generates, stores, regulates, and distributes electrical power
Attitude Control	Provides determination and control of attitude and orbit position
Communication	Communicates with ground and other spacecraft
Command and Data Handling	Processes and distributes commands and data
Thermal	Maintains equipment within allowed temperature ranges
Structure	Provides support structure and booster adaptor
Payload	Mission-peculiar equipment, instruments, and/or sensors

compared to 33 per cent in 1990 (Euroconsult 2005, 24). This trend is further amplified when one also takes into account the world's military space budgets over the same period. These investments, calculated to be around C\$22 billion in 2004, have been almost exclusively applied to space applications (Euroconsult 2005, 24). In contrast, CSA's budget has decreased the proportion devoted to utilization (Euroconsult 2005, 95).

Of course, technological investment for exploration can have utilization value, but this requires a conscious attempt to invest in crossover areas. Regardless, the ongoing expansion of space utilization holds great opportunities and challenges for nations like Canada. It also has security implications in terms of the nation's well-being: one path leads to technological leadership and industrial competitiveness, while the other brings foreign space reliance and vulnerability. Alongside future observation and communication opportunities, new economic prospects await the emergence of on-orbit satellite maintenance and sub-orbital transportation. Perhaps indicative in a historical sense, Canada developed a major air industry by building on the expertise acquired following World War I. There is little indication that the nation is preparing to do so again with respect to an analogous trend in space utilization.

Canada and Space Exploration Trends

While space utilization focuses on using space for terrestrial purposes, space exploration is concerned with looking outwards to the solar system and beyond. Exploration and adventure were the first drivers of early space thought. This was the space of lunar, interplanetary, and interstellar travel and enlightenment, the space of Jules Verne and H.G. Wells, and the space of the Star Trek and Star Wars entertainment franchises and their legions of devoted fans. It was also the space that drove the efforts of the early space engineers, Korolev (USSR) and von Braun (USA), in their Cold War race to the Moon. Today, it is the space of the ISS and a host of unmanned Mars missions, as well as the aforementioned planned return to the Moon as a stepping stone to Mars.

Space exploration wins most people's hearts and imaginations, but it offers limited immediate returns to meeting humanity's mundane, daily needs. Space exploration is about investing for the long term and exploring the cosmos' ancient past and distant future. Among the G8, Canada leads in the percentage of its national space budget dedicated to exploration (Euroconsult 2005, 31).

Space exploration has been an arena of hopes, dreams, and unfortunately, various disappointments. Perhaps most indicative is the aftermath of the 1960s race to the Moon. On the day Neil Armstrong set foot on the Moon, the willingness to apply further resources to exploration dramatically declined; it has remained far below its peak investment levels ever since. Certainly, agencies like NASA (USA), ESA (Europe), and JAXA (Japan) spent very large sums on space science and exploration. But these expenditures have fallen far short of the resources needed to return to the Moon or to fund human travel beyond. The situation has only worsened since the beginning of the costly and troublesome ISS initiative, which now stands at double its initial costs and time estimates, at C\$100 billion and twenty years respectively (Teal Group Corporation 2006).

Exploration holds a fascination for many people, and the search for the building blocks of life on Mars (water) has been partially driven by the hope that success will spark greater investment by appealing to this fascination. Regardless of the results, **the next fifteen years appear to hold some promise of greater space exploration, as evident in the recent American Moon initiative. This time, however, China is the competitor.** This context is very important; the necessary expenditures demand formidable justification, given the long-term nature of possible payoffs from exploration.

In the first space race, from approximately 1957 to 1972, the justification and willingness to proceed was intertwined with, and fuelled by, the Cold War and the incredible need to justify the opposing economic and political systems. The United States Apollo Moon program cost three

lives and the equivalent of C\$150 billion today (Zaehringer 2004). This does not include the price paid by the Soviet Union for its N-1 Moon program, or the upfront costs both countries paid to develop initial space access and expertise. In the end, the justification was unsustainable, as was the level of investment. As a result, space exploration has been less ambitious for the last thirty years, and from a public perspective, less meaningful and fulfilling.

On 14 January 2004, President George Bush announced his Vision for Space Exploration that included these expectations: a return Moon landing by 2020, and to reach Mars by 2030. Interestingly, the same Mars vision was proclaimed by George Bush Senior in 1989. Differences this time include a shorter timeline to completion, a more focused objective, a legitimate and willing competitor, and a conservative technological plan. For its return to the Moon, the United States plans to use the same Apollo-type, expendable system (NASA 2006) as it did forty years ago.

Whether the new Moon initiative can be sustained remains to be seen. In addition to the support it will enjoy amongst the community of national and international civil space organizations (including Canada's CSA), much will depend upon the nature and significance of the new race. China, which has operated its Long March family of rockets since the 1960s, has dramatically increased its space investment over the last ten years, implemented its own human space flight program, and committed itself to go to the Moon. It became the third nation to orbit an astronaut independently in October 2003 with the Shenzhou 5 spacecraft. Its Chinese manned space program, Project 921, has as its goal a lunar orbiter this year, an unmanned lunar landing in 2010, and a space station by 2020.

While some may argue the return to the Moon is a step backwards, the Moon race and the United States' vehicle decision may jumpstart a relatively stalled global exploration agenda. The race, if it develops some momentum, has the potential to draw Russia, ESA, and Japan into the competition, and Canada as well. But it is also a race that could be easily sidelined by a major economic downturn in the United States or globally, or by the emergence of a major American or global crisis of one kind or another.

A return to the Moon will conservatively cost C\$100 billion, and the price of a manned Mars mission could well be C\$500 billion dollars (Teal Group Corporation 2006). While significant advances have been made in a variety of technological fronts since Apollo, the basis of manned exploration is extreme speed over a sustained period. An inexpensive propulsion system remains a distant dream. While nuclear propulsion offers the most readily available alternative and is a significant improvement over chemical propulsion, public opposition to all things nuclear remains relatively strong, notwithstanding the possibility that global warming may alter public perceptions. Regardless, nuclear energy is emphasized in the recent *United States Space Policy* released in October 2006 (White House 2006, 7)

Space exploration will remain where the heart and imagination reside. It entails relatively exorbitant costs and risks coupled with a very distant and unknowable return on investment. It is a combination that does not inherently engender strong, sustained, political will and investment, including in the United States or Canada. Yet Canada, through the stewardship of the CSA, has over the years increasingly committed its small and declining budget to space science and exploration and to the exploration interests and programs of other space agencies, particularly NASA and the ISS. Almost 50 per cent, or C\$155 million, of the CSA's C\$330 million annual budget is dedicated to space science, exploration, and awareness, roughly twice the figure allocated to space communications and remote sensing development (Euroconsult 2005, 95).

Security implications of a return to the Moon, like the destination itself, are remote. However, **a return to the Moon could significantly push space systems developments, particularly in the United States, and that could further expand Canada's growing space capability gap, and/or further focus Canada's scarce space investments into exploration rather than access and utilization initiatives.** Either case entails national security implications.

Conclusion and Recommendations

Today, space activity closely resembles that of the high seas of times past; an international territory, with many unknowns and uncharted reaches, used by a growing spectrum of public and private users from around the world, including Canada. However, it is also dominated, controlled, and managed by those few who invested in independent access. Of those, a single national actor, the United States, overwhelmingly dominates the field in security and commercial terms. The United States, along with Russia, Europe (through France), Japan, China, and India largely drive today's space agenda, and these countries will likely determine its future.

Space access will inevitably become measurably more affordable, reliable, and available, and as that happens, utilization opportunities will broaden and deepen. Today, somewhere on the order of 700 active satellites are circling the earth, and that number is being replenished and expanded by the launch of one or two new satellites a week, on average. Space is en route to becoming busier, particularly in the sub-orbital to low-earth-orbit domains.

The lower regions of space enjoy more immediate potential worth as well as inevitable growth, thus it should not be neglected. But it is the world of space science and exploration that has increasingly dominated Canada's space agenda and the public spending of space dollars over the last fifteen years. This is not surprising, given the manner in which Canada's space history unfolded, but it is worrisome for Canada's future interests, concerns, and influence in space. **If Canada's space trajectory continues as it has, the coming two decades will likely witness two contradictory trends in Canada. Space use and reliance will progressively increase, while Canada's public and private domestic capacity to safeguard its space interests will decline comparatively.** In other words, security concerns will increase, but Canada's actual influence in this domain's future development may well decline.

Recommendations include:

- **substantially increasing the national investment in space, which has been flat for fifteen years;**
- **further space exploration investments ought to be curbed, unless advanced technology and foreign policy gains are overwhelmingly present;**
- **expanding space utilization initiatives and research and development, starting with the follow-up to Radarsat II, Project Epsilon II; and**
- **revisiting space access, particularly considering evolving air-launch and small-satellite launch technologies and their operational and foreign policy cost/benefits.**

CHAPTER 3

Canada, Defence, National Security and Military Space

Introduction

Defence has traditionally been the primary consideration in national security deliberations, thus it has also always been a significant driver in the exploitation of outer space. Initially, DND was the primary actor and investor in outer space research and development, especially in the field of rocketry or ballistic missiles. National Defence also largely drove the first generation of communication and surveillance (remote sensing) developments. In turn, these developments were driven by the respective strategic defence interests of the two superpowers, the United States and the Soviet Union, which dominated space for most of the Cold War era.

As a function of their dominance, the manner in which space was exploited and managed was largely a result of their interests. All of the other actors, whether civil, commercial, or national, responded to the agenda set by the superpowers and their strategic interests. Even today, despite the significant changes that occurred since the end of the Cold War, the defence and national security interests of the world's leading political-military and space power, the United States, continue to dominate the global space agenda and its future.

Most countries have followed and responded to the initiatives, policies, research and development programs, and activities of the dominant political-military powers of the day. This is especially true of Canada. Its response or strategy for space has been largely premised upon its close bilateral relationship with the United States, a relationship which extends across the civil, commercial, and defence sectors. For most, if not all, of the Cold War, this strategy/approach produced significant payoffs. Of course, Canada and the DND had few alternatives owing to the high cost of military space, the dominance of strategic nuclear deterrence considerations, and significant defence budget constraints.

For all intents and purposes, this fundamental strategy and the factors and principles that guided National DND early on are still in place. The net result for DND is continued reliance and dependence upon American military space; on access to American launch capabilities and to American military satellites for information, and on the United States' willingness to provide unfiltered defence information about, and/or derived from, military space, in addition to the use of their commercial systems.

This dependence has not proven overly problematic in the past. However, **the significant changes currently underway in American military space thinking and employment indicate that, at least minimally, the DND, the CF, and thus Canada, will have to do more in future, including becoming a more active and valued military space player.**

This is not to suggest that Canada can afford to become a space power rivalling even the second-tier space powers like China and India. On the contrary, the country's strategic relationship with the United States should remain the centerpiece of Canadian military space strategy, just as close co-operation with the United States regarding defence should remain the nation's overall defence strategy. However, not only will Canada have to invest more in military space to ensure continued payoffs, but the nation, led by DND, needs to consider closely those unique Canadian national security requirements that will necessitate selected independent capabilities.

In order to accomplish this, DND and the CF must first recognize that the conditions that produced success during the Cold War have changed. Canadian access to American military space has declined despite the agreement to assign the American ballistic missile defence early warning mission to NORAD, especially in the wake of the Canadian government's decision not to participate.

The Department of National Defence must also recognize that military space is changing, and that change entails direct implications for Canadian defence and national security requirements. Military space is becoming more than just an environment for certain capabilities related to modern terrestrial military operations. It is becoming an environment with its own strategic logic, as land, sea, and air currently have their own logic. Notwithstanding the logic of co-operation that guides CF thinking, a foundation should be laid to treat military space the same way land, sea, and air are treated, and to develop national capabilities essential to Canada's independent requirements, especially as they relate to the surveillance and monitoring of Canadian territory.

In examining the ongoing inter-relationship between global military space and Canada's response to it, the obvious focus is upon the United States, given it is Canada's closest and most important ally. In so doing, it begins with the Cold War era of military space when its strategy emerged, turns to the contemporary era of operational military space and the enunciation of Canada's first defence space policy, and finally, considers military space's future and Canada's defence and security requirements therein.

Strategic Military Space and the Foundation of Canadian Strategy

Similar to civil or commercial space, military space is made up of the following:

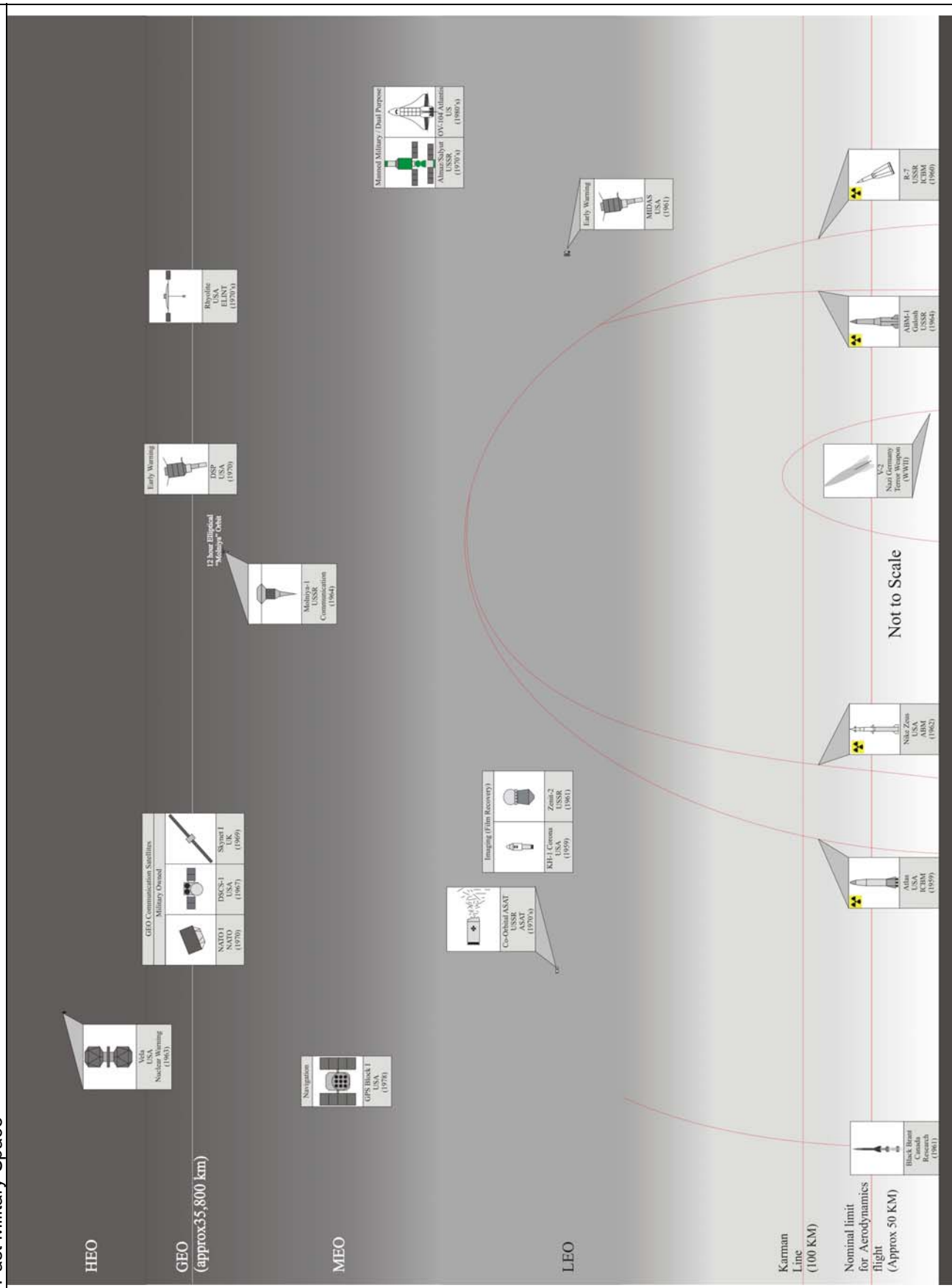
- the missiles or rockets possessed by military forces, provided by other government agencies or by the commercial sector, which provide access to, or transit through, space;
- the payloads that orbit the earth (satellites) or transit through space (including warheads) that are used for explicit defence or military purposes, whether they be owned by military, civil, or commercial entities;
- the signals, wavelengths, or frequencies over which defence or military information is transmitted from the payloads to the military user; and finally,
- the military stations (ground, sea, or air) or end points which receive the information, including the analytical capabilities and skills necessary to convert the information into useful military forms.

Initially, space was almost exclusively the purview of the two superpowers and their strategic nuclear deterrence and defence requirements. Their requirements began with the development of long-range ballistic missiles armed with nuclear warheads, either land or sea-based, which became the backbone of their respective nuclear postures and deterrent strategies. Concurrently, investment was also directed to the exploitation of higher orbits (particularly geostationary for strategic communication and early warning systems) and lower orbits for the purpose of gathering intelligence (fig. 3.1).

The development of hardened military communications satellites ensured that communications could be maintained in the event of a nuclear war, leaving the national command authority in control. The first generation of earth observation satellites obtained intelligence on the other's strategic military capabilities and provided early warning of a ballistic missile attack. They also provided the national technical means for verification in the first generation of arms control agreements. Finally, the first generation of navigation satellites (the future Global Positioning System), served key targeting functions, particularly for submarine launched ballistic missiles, the backbone of second strike or retaliatory forces.

The early space years were dominated by military and strategic interests, notwithstanding the very high profile race to the Moon and the genesis of commercial space activity. Ballistic missiles were purposely separated and excluded from space, with space implicitly

Figure 3.1



defined as an object completing a single orbit. Space was conceptualized the same way international waters or the high seas were, providing freedom of passage while the vessels (satellites) transiting through space were flagged as national property. Freedom of passage legalized the transit of spy satellites on orbit over an adversary (Peterson 1997).

The deployment of weapons of mass destruction (WMD), particularly nuclear weapons, on orbit was also prohibited, in part because of the strategic dangers to deterrence stability if one or both sides possessed the capability to launch a surprise nuclear attack with little warning. The United States and the Soviet Union also agreed to ban the testing of nuclear weapons in space with the 1963 *Limited Test Ban Treaty*, which is now part of the *Comprehensive Test Ban Treaty*.

Within this overall strategic nuclear environment and Cold War politics, a limited international legal regime followed the OST with the *Rescue of Astronauts Agreement* (1968), the *Registration Convention* (1969), the *Liability Convention* (1976), and the as yet unratified 1979 *Moon Treaty* (app. B). Elements of the OST also gave birth to the idea of outer space as a sanctuary from war and weapons, drawing, for example, on the phrase “exploration and use of outer space for peaceful purposes” (OST 1967).

Importantly, no part of this legal regime explicitly prohibits either the use of any weapons in outer space, including nuclear weapons, the transit of weapons through space, the deployment of weapons in outer space for possible use against targets in space or below (except WMD), or any other orbital military activities. Indeed, the establishment of the Conference on Disarmament’s Prevention of an Arms Race in Outer Space (PAROS), along with repeated, unsuccessful diplomatic attempts to negotiate a formal international treaty on weapons in space, speaks to the reality that space is not a legal sanctuary.

As far as sanctuary from a strategic perspective is concerned, the two protagonists intuitively recognized that a stable nuclear deterrent relationship required assured command and control of forces. Thus, both had an interest in tacitly agreeing to leave each other’s strategic space systems alone, and this agreement, alongside technical constraints, informed their limited anti-satellite (ASAT) weapon’s development programs; focusing away from strategically vital geostationary in favour of the lower, tactically focused orbits. At the same time, significant technological and cost barriers existed to weaponization generally (Stares 1985a).

With space dominated by the strategic interests of the two superpowers, alongside the prohibitive costs of participating in military space, most states, like Canada, remained on the margins. Their engagement was partially informed by their respective political alignments during the Cold War and partially by the possibilities that emerged over time as technology matured and diffused.

In a situation similar to that of many nations during the initial years of space development, Canadian space policy was led by the DND. Initial rocketry and a range of other communications and experimental space activities emerged out of the defence research group. Alouette 1, Canada’s first communications satellite marking Canada’s entry as the third nation in space, was a military program in the Defence Research Telecommunications Establishment (DRTE). The fact that Alouette I was also launched by the United States holds some significance for the evolving strategy and future pattern of space engagement.

By the 1970s, Canadian space leadership had passed from defence to the civil and commercial arenas. Following the 1967 *Chapman Report’s* recommendation, a national launch capability was rejected on grounds of cost and the ability to obtain access to space from the United States. In 1969, DRTE and its programs were essentially transferred to the Communications Research Centre in the Department of Communications.

The withdrawal of the DND from a lead role did not entirely end departmental involvement. The Department of National Defence continued some space research, such as high altitude and remote sensing, in the Defence Research Establishment Ottawa (DREO). This was subsequently

renamed the Research and Development Branch of the Chief of Research and Development (CRAD) in 1974, followed sixteen years later by the creation of Defence Research and Development Canada (DRDC).

Numerous factors informed the government's decision to shift leadership from defence to the civil and commercial side. These included, *inter alia*, a general shift in the Canadian body politic to the left, which was informed by rising nationalism, a national independent economic development thrust, and the impact of the war in Vietnam on the public's level of support for defence. Also, Canada's non-nuclear policy made military space somewhat problematic owing to the dominance of strategic deterrence considerations.

For DND, cost alone prohibited any significant major investments in military space, especially in light of funding cuts in the 1960s and '70s. In addition to managing the implications of budget cuts on the capabilities of the CF, attention was also focused on the implementation of CF unification and integration, as laid out in the 1964 *Defence White Paper*, followed by other administrative reforms in the 1970s (Bland 1987). Despite these factors, the Department of National Defence could still maintain a place in military space by virtue of Canada's unique defence relationship with the United States through the binational North American Air (Aerospace in 1981) Defence Command (NORAD).

Building upon its core mission of the defence of North America against a Soviet bomber attack, which included early warning radar lines deployed across Canada, the addition of the early warning mission for ballistic missile attack made obvious strategic sense, even though there was no defence against such an attack. In a simple military division of labour, Canada provided the radars for warning of air attack (under a very favourable spending arrangement in which the United States initially paid for two-thirds of the capital costs), and the United States supplied the sensors (space and ground) for early warning of a ballistic missile attack.

The ground-based ballistic missile early warning system (BMEWS) of radars was deployed in the 1960s at Clear, Alaska; Thule, Greenland; and Fylingdales (in the United Kingdom). It was augmented with the first space-based component (1970) to provide early warning information: the Defense Support Program, consisting of infra-red sensors in geostationary orbit.

Canada's direct contribution consisted of personnel and assessors devoted to the early warning of a ballistic missile attack inside the Missile Warning Operations Centre (now known as the Missile Correlation Center), as well as two ground-based, optical sensors (Baker-Nunn cameras, now retired) that supported the space surveillance mission. These cameras were part of the American Space Surveillance Network (SSN), consisting of ground-based sensors, both radar and electro-optical (including the ballistic missile early warning radars as contributing sensors), and a single, space-based sensor (fig. 3.2). The SSN tracks objects, including debris, in space. Strategically, it ensures that any orbiting or de-orbiting object is not confused for a missile warhead, thereby triggering a false alarm with potentially horrendous consequences. It also serves a range of civilian functions, for example, de-conflicting orbits and ensuring the safety of the space shuttle from orbital debris.

Canada's close defence relationship also spilled into the field of intelligence. As a partner in the aerospace defence of North America, this required Canadian access to intelligence information from and about space, including the capabilities of adversaries like the Soviet Union and China. Canada's defence research establishment also continued to work closely with the United States in space with only limited investment. Building on Canada's research effort on ballistic missile defence in the late 1950s, Canada participated, for example, in Project Teal Ruby in the late 1970s and the 1980s. The project was designed to test high atmospheric surveillance for tracking bombers and missiles (Mueller 1986).

Figure 3.2

Defense Support Prog



This was the extent of DND and CF's participation in military space during the Cold War. In comparative terms, little was directly invested and no operational military satellites were acquired. Given the high costs of independent engagement, there was little more Canada could arguably contribute, especially with military space predominantly residing in the high rent, orbital areas, unless a decision was made to sacrifice some other major military capability given the fiscal environment. Furthermore, one would be hard pressed to identify any unique benefits the nation or the CF could accrue by an independent initiative, especially with Canada's position outside the nuclear deterrence world and its direct access to key information from military space resulting from its relationship with the United States.

At the same time, military space within the organization was the almost exclusive purview of a small Air Force cadre assigned to NORAD. For the majority of the Air Force and all of the Army and Navy up through the senior ranks, space was more or less irrelevant given much more pressing military demands. There was also no group or directorate within the Department of National Defence devoted to space, except for scientists and engineers on the research and development side.

The Department of National Defence's direct engagement in military space was also constrained, as noted above, by broader Canadian foreign policy. External (now Foreign) Affairs (DEA) was very active in the process leading to the OST and to associated elements of the legal regime. From its perspective, the only way to manage military space was through diplomacy or arms control. In so doing, External Affairs sought to move the policy of non-weaponization forward through an extension of the legal regime. This gained momentum with Trudeau's call for a ban on the development, testing, and deployment of weapons in space at the United Nations' Special Session on Disarmament (UNSSOD II) in 1982 (Legault and Fortmann 1989). In addition, DEA championed space-based surveillance for arms control verification purposes, although nothing was invested in terms of a national capability (Centre for Research of Air and Space Law 1987).

For most of the Cold War, the Department of National Defence and External Affairs could co-exist in military space with Canada at an arms-length distance from the United States' strategic deterrent. External Affairs accepted the reality of space being militarized, but not weaponized. It opposed any attempt by nations, primarily in the UN Committee on the Peaceful Use of Outer Space (COPUOS), to roll back the clock or alter the fundamental foundation of the legal regime as being open to freedom of passage as advocated by certain equatorial states (1976 *Bogota Declaration*).

Moreover, non-weaponization did not initially prove problematic for DND's strategy. Both DND and DEA were aware of the respective ASAT research and development programs of the two superpowers in the 1970s and 1980s. Moreover, the existing legal regime did provide some protection once the now defunct *Anti-Ballistic Missile Treaty* (1972) with its prohibition on missile defences in space was signed.

The relatively comfortable co-existence between the Department of National Defence and External Affairs regarding military space began to change in the wake of President Reagan's Strategic Defense Initiative (SDI) speech in March, 1983, which set as a goal the creation of a missile shield for the defense of the United States, if not the world, from ballistic missiles. Almost immediately, SDI became known as "Star Wars," and the missile shield as "Weapons in Space."

At the same time, other concerns about weaponization and related space security issues emerged within External Affairs. This extended, for example, to Canada's involvement with the United States' Space Shuttle as a possible weapons platform, especially with the Canadarm as a potential means to 'grab' satellites. Similar fears were generated around the International Space Station (ISS), especially over its status in case major hostilities broke out amongst the parties.

Alongside these elements, Canada's military space strategy was directly affected by the 1985 Mulroney SDI decision not to officially participate in the research program (while still allowing Canadian companies to do so). In the wake of that decision, Canadian access to American

military space began to decline, and Canadians were barred from not only American strategic planning for military space, but also from elements of American planning for the aerospace defence of North America.

Canadian access recovered in the 1990s. Nonetheless, the limits of the strategy based upon dependency began to appear. As such, one might expect that these developments would provide occasion for a major re-evaluation of Canadian strategy on military space. Moreover, the need not only followed from the specifics of SDI, but from the more subtle implications of the Reagan speech for the future of military space as it had been understood thus far.

Reagan called into question the future of nuclear deterrence as the cornerstone of international peace and security. In so doing, he implicitly suggested a new strategic world, and that such a world would mean a different type or form of military space. Indeed, developments were slowly emerging that indicated new and different roles for space based upon new technologies, albeit separate from SDI's missile defence focus.

However, there was no major re-think, not between the two major departments, at least. The strategic defense initiative and subsequent events over the next decade would in some ways accelerate weaponization concerns within External Affairs. The DND would also take a small step forward following the recommendation from the Joint Parliamentary Committee that a military space program be initiated (Godefroy 2006), thus leading to the first defence *Space Policy* (1992), the creation of the Directorate of Space Development, and the initiation of the Joint Space Project with the United States. None of these acts, however, had a significant impact on the fundamentals of Canadian defence and security policy regarding space, which was to leverage the close defence relationship with the United States to obtain access to American military space while limiting national investments.

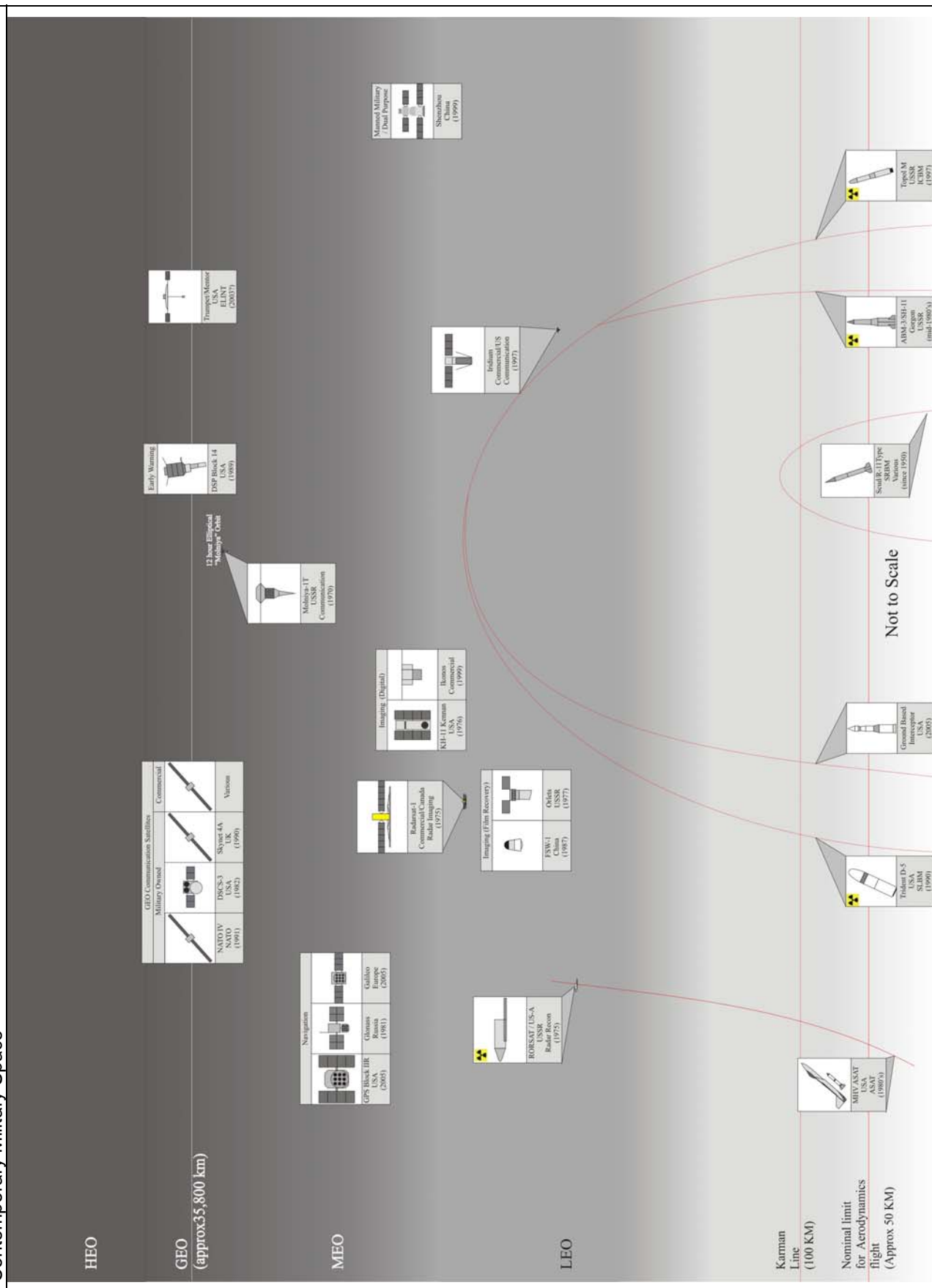
Operational Military Space and Canada's Strategy

As a function of new technologies and the new geo-strategic environment that emerged after the Cold War, a new or broadening employment for military space assets presented itself, particularly for the United States; large scale space employment in support of worldwide conventional land, sea, and air operations. Thus began the era of operational military space (fig. 3.3).

The first glimpse of the value of space in conventional military operations was the use of weather satellites in the latter stages of the war in Vietnam. From there, space-based information capabilities swiftly evolved, largely as a function of the computer revolution and the computer's ability to acquire, hold, and move huge amounts of information quickly. However, it was not until the 1991 Gulf War, frequently referred to as the first space war, that the immense value of improving space-based assets for conventional operations was fully recognized.

Labelling the Gulf War as the first space war is somewhat misleading, in that it creates images of what is, in effect, the future of military space. There were no military engagements in space, and except for Iraq's re-engineered SCUD missiles transiting through the lower reaches of space, nothing was directly destroyed by space assets. Nonetheless, space proved an invaluable force multiplier in support of American and coalition forces in replacing or enhancing support from traditional terrestrial capabilities (land, sea, and air). Weather satellites provided accurate forecasting for military planning and execution. The Defense Support Program, through NORAD, provided early warning of SCUD missile attacks to the military and political authorities in Saudi Arabia and Israel, a task which is today also performed by the in-theatre, Joint Air-to-Ground Station (JTAGS).

Figure 3.3



Satellite communication links enhanced command and control arrangements in the field, both amongst the operational commands and with the national command authority halfway around the world. Remote sensing enhanced target identification and planning. The GPS facilitated the coordination of units in the field both horizontally and vertically. Direct concerns about the possibility of Iraq employing commercial space also led to the first, and arguably unique, counter-offensive space operation. The United States purchased all commercial imagery over the theatre of operations in order to deny Iraqi access.

Since then, space has become an indispensable force in itself for all American military operations. **Accordingly, space is seen in American military circles as a centre of gravity for its armed forces.** During the Cold War era, there was no need to develop an independent strategy about military space, because nuclear deterrence informed activities. Nor has it been the case that operational military space has really required an independent strategy or body of relatively unique strategic thought, such as that which accompanied nuclear weapons.

As a force enhancement tool, operational military space largely falls into existing land, sea, and air thinking. With reference to the army or land forces in particular, space is simply the ultimate high ground; it is the ideal venue for overcoming terrestrial limitations in communications and observation, enabling the more efficient and effective employment of armed force.

Nonetheless, space has also become somewhat synonymous with the revolution in military affairs concept that emerged during the 1990s (Lambeth 2003). Rapid communications and intelligence, surveillance, target acquisition, and reconnaissance (ISTAR) capabilities from the ultimate high ground of space revolutionized the battlefield in two ways. First, the provision of near real time information about the battlefield ostensibly lifted the fog of war, providing commanders with an accurate view of the disposition of friendly and enemy forces, their respective capabilities, and their progress or activities over time.

Second, this relatively accurate picture and the means to communicate rapidly ensured greater efficiency and efficacy in the employment of one's forces. More efficient and effective use of forces, especially when married to new, precision-guided munitions (PGMs) like the GPS-guided, Joint Direct Attack Munitions (JDAMS), promoted, if not enabled, the ongoing shift from labour intensive, mass warfare to technology intensive, precision warfare. Since the Gulf War, the United States has fully integrated space into its operational command structure and process. Space has been integrated into operational joint command headquarters along with dedicated space positions tracking, inter alia, weather in space, and allied and adversary, as well as commercial, satellite availability and accessibility for military operations.

Commercial space (or commercial satellite services) is another of the significant new attributes of operational military space. It has brought space to a relatively affordable level for many states, and the capabilities of commercial space, especially in remote sensing, are beginning to rival those of dedicated military surveillance and intelligence satellites. Depending upon ownership and national legislation or regulations, anyone can buy access to satellite communications and satellite imagery.

As for navigation (which includes targeting and ordnance guidance), GPS is an international public good available to anyone. Its public signal (c/a code) can be accessed and employed by anyone for commercial or military purposes. The technology and knowledge to do so is also diffusing rapidly. Most importantly, due to its widespread commercial use, the possibility that the United States would turn the signal off for military-security reasons is remote, as it would create havoc. The Global Positioning System's second encrypted signal, used by the United States military (and other secure government departments and agencies) and at its discretion by its allies, is much more accurate for precision warfare purposes. Regardless of which code a state can access, GPS is a force multiplier. It improves targeting accuracy and reduces the number of attacks necessary to destroy a particular target. With the Russian Glonass system being re-

constituted and the future European Space Agency's Galileo navigation system, the accuracy of a publicly available signal may well increase.

The availability of commercial space communications, imagery (remote sensing), and navigation to most, if not all, armed forces around the world opens the door for all states to exploit space in a force enhancement role. With the United States fully committed to space and being the dominant political-military power (and space power), the rest of the international community has little choice but to follow, one way or another. Potential adversaries and non-aligned states ignore space in a force enhancement role at their own political and military peril. Allies, in particular, have little, if any, choice but to follow if they wish to remain functionally inter-operable with the United States.

Though space, either in terms of access or of assets (satellites), is still expensive, the developments that made operational space possible opened new opportunities for states which could not afford space in the past. As potential end-users, commercial space provided a cost-effective alternative to dedicated national military space assets. In addition, overall costs have declined to the extent that many states can now begin to contemplate developing their own dedicated military space capabilities.

As detailed in chapter 2, launch costs have declined over the past decade for several reasons. Greater efficiency was achieved in propulsion technologies. The size and weight of satellites shrank even as their capability grew. Launches and satellites became more reliable. New launch concepts emerged. Low earth orbit, in many ways the home of operational space, is relatively cheaper to access than geostationary space. States can even entertain the possibility of developing and sustaining a light launch capability to provide some degree of assured access for defence purposes. The ongoing proliferation of ballistic missile capabilities amongst states such as Iran and North Korea also provides a nascent space launch capability.

Alongside states, the diffusion of end-user technologies also opened up opportunities for insurgencies and terrorist organizations to exploit space, including the possibility of employing counter-electronic jamming and spoofing techniques against states relying upon non-encrypted, commercial signals. Through sophisticated international networks, they can also procure commercial imagery that can be used to plan attacks. As commercially available, space-derived information grows, so will the ability of such organizations grow to exploit space, even if they lack the resources and ability to strike directly at space-based assets themselves.

The incentives and disincentives for nations other than the first-order, space-faring military space powers to invest more in space-based capabilities vary widely. In this context, the implicit goal of ensuring CF inter-operability with American military forces for Canada and DND, as evident in *Strategy 2020* (DND 1999), leaves the country little choice but to engage in operational military space. The renewed attention paid by the CF to space in the 1990s largely reflected this reality. The continuing problem is the lack of adequate resources for large investments in space without eliminating other highly valued military capabilities. The answer has been the same as the Cold War strategy; reliance upon access to American military space as an end-user.

On a basic reading of the overly ambitious 1992 and 1998 space policies, one might easily conclude that DND was about to embark on a major independent effort in space. For example, the 1998 policy covers the waterfront in terms of the employment of space for defence and security purposes; "to protect national security and sovereignty interests; to protect national interests from threats located in or passing through space; [and] to fulfill Canada's defence commitments by supporting missions and tasks using space technology wherever appropriate" (DND 1998, 2).

However, while directly referencing the fundamental importance of a "comprehensive space capability," the means to do so emphasizes the end user side of the equation. In so doing, the current *Defence Space Policy* stresses the importance of international and domestic co-operation with other government departments and agencies. Furthermore, it notes that "Canadian

contributions to collective space efforts will help ensure access to allied space intelligence, facilities, and data.”

Nowhere does the policy speak directly to an independent, dedicated, national, space-based capability. Instead, the leverage strategy is clearly evident, as it is in the steps taken by DND following the creation of the Joint Space Project, namely the establishment of Project Sapphire; the contribution of a single optical space-based space surveillance satellite to the American SSN that ostensibly replaces the retired Baker-Nunn, ground-based sensors.

Having received assurances of future access, DND has also invested in the United States’ advanced, extreme-high-frequency (AEHF) military satellite replacement of the secure MILSTAR communications system. This capability is expected to be operational between 2008 and 2009. Until then, the CF continue to rely on commercial satellite communications, including the apparent use of the Iridium network (which was rescued from bankruptcy by the United States’ Department of Defense).

In addition, the CF has also taken steps to access American operational military space more effectively. They recently acquired the receivers for the encrypted GPS signal. Also, the Joint Space Support Capability Project is designed to demonstrate the value of integrating space into joint command centres, similar in nature to the integration of space already in place within the American operational command structure. In October 2005, this capability was formally tested during Exercise Phoenix Ram, and it should become operational sometime in the foreseeable future.

End-user reliance on others is also evident in the relationship between DND and the Canadian Space Agency (CSA) over radar remote sensing. The CF did not invest directly in Radarsat I, but it has acted as a client for the commercial entity created by CSA. In the case of Radarsat II (expected to launch within a year), DND invested only to the extent of adding an experimental ground target moving indicator (GTMI) to the satellite. Otherwise, DND will still be primarily an imagery client.

As formally announced in the summer of 2005, Radarsat imagery will be downloaded to ground stations under Project Polar Epsilon I. They will be co-located on both coasts along with the existing Marine Operations Centres for the surveillance of national territory, and there may be another ground station in the interior. In this regard, DND is investing in the ground stations and will do its own analysis. Imagery costs, however, are expected to be drawn down from the government’s initial investment of C\$450 million in Radarsat II, rather than directly from DND’s budget.

Representing a potential shift from past behaviour, DND is also investigating participation and investment in the planned CSA radar constellation follow-up to Radarsat II through Polar Epsilon II. The constellation requirement has been partially driven by growing sovereignty and security concerns about Northern Canada and the Arctic. Whether DND funding is provided and the constellation proceeds remains to be seen. Regardless, there are no plans for the CF to gain any actual operational experience with the satellites, just as there are no plans for CF to be engaged in flying any of them, including Sapphire.

Radarsat II is an interesting case illustrating the limits of dependency. Whereas Radarsat I was launched by the United States (as all preceding launches have been nominally cost-free) in exchange for imagery, the United States refused when it came to Radarsat II. After lengthy discussions with the United States (and an acrimonious internal debate between CSA seeking an alternative launch and DND and Foreign Affairs seeking to maintain the status quo), a launch agreement was reached in which Canada agreed to develop and implement legislation (the *Remote Sensing Space Systems Act*, November 2005) governing the dissemination of data, shutter control, licensing, and priority access.

Whether Canada should have had legislation governing imagery is moot. Radarsat II is a story about the limits of dependency and the vulnerability it creates. In this case, Canada had little

choice, owing to the technology transfer restrictions through the United States' International Trade in Arms Registry (ITAR) and the political ramifications should Canada obtain its own launch capability elsewhere, given that Canada had no indigenous capability.

Dependency raises other concerns, which DND and the CF has thus far been willing to accept. Access arrangements through memoranda of understanding (MOU), among other types of arrangements, provide some surety of access to the CF. But it is not necessarily the case that the United States, like any other state, will disclose everything that a close ally like Canada might want or need in every circumstance. In the interest of national security, some restrictions must be placed on information and/or on access to information with respect to space-derived materials. Access is also constrained by American priorities. If a choice must be made, American forces will come first. Canadian access to the American AEHF satellite communications is not entirely open ended.

Accepting dependence upon the satellite or space services of others still demands investment in the capacity to employ and integrate the information without relying upon others. It requires a dedicated space cadre, something which barely exists within the CF. It demands investment in education and training and the creation of a space career path within the CF. The 1998 *Space Policy* recognizes the vital importance of a "trained cadre of civilian and military personnel ... to the effective performance of space-related defence activities" (DND 1998, 6). It also promises to "establish a framework for educating, training, and employing DND and CF personnel in space positions" (DND 1998, 6).

However, no such framework appears to have been created. There are a range of space educational opportunities in Canada and the United States for CF personnel, but there is neither a real space operational role for personnel to return to, nor a career path that might attract the best and the brightest within the CF in general and the Canadian Air Force in particular. In the absence of such a career path, dependency on others extends even deeper than just satellites and the technology to access and employ them.

Neither have dedicated, operational "space positions" been established within the CF, notwithstanding the few positions within Joint Capabilities Programmes Space, the successor of the Directorate of Space Development. Certainly, Project Epsilon I will necessitate the establishment of end-user analytical positions. For now, the handful of existing Canadian space positions are found with NORAD and the United States Air Force Space Command (14th Air Force). Negotiations are also currently underway to place a couple of Canadians at the Space Operations Center at Vandenberg Air Force Base in California when the Center in Cheyenne Mountain closes. Most importantly, the presence of Canadians in American military space positions has declined significantly over the past several decades. In the past, Canada was alone among the allies. Today, Canadians will join the Australians and the British at the Vandenberg base.

The CF, having recognized the growing importance of space for military operations over the past decade or so, has been unable to respond fully, in part because of fiscal and resource constraints. Roughly a decade of budget cuts from 1989 on presented a major obstacle to space investment. In addition, resources have been limited due to the high level of overseas commitments during this period. Even with the increased funding and additional resources that accompany the recent planned expansion of the CF, the vital need to rebuild, re-equip, and modernize the CF, alongside the demands of meeting Canada's overseas military commitment to Afghanistan, leave little room for space investment and space resource allocation. Unless more funding is acquired, any significant space investment may have to be made at the expense of other pressing military capabilities.

At the same time, however, the lack of investment in space is a function of several other important factors. First, defence and military space is still in its relative infancy. It must compete with well-established beliefs and values held within the three services (army, navy, and air force) about what are and what are not essential military capabilities. In this context, service or organizational beliefs are likely to continue to value traditional capabilities: armoured vehicles and

troops in the army; ships in the navy; and planes in the air force. As such, space investment and assets will tend to be secondary to traditional capability investments, regardless of the amount of money available.

Second, the success of the CF's military space strategy in the past acts as a barrier to future investment. Reliance upon relatively assured access from the United States primarily as an end-user is taken for granted. Yet the relationship with respect to access to American military space is changing, as noted above. By saying no to missile defence, Canada said no to military space in many ways. Much of missile defence, independent of weapons in space, will be space based (tracking and cueing sensors, for example). These same space-based elements also serve other military support functions. As such, the amount of access Canada will receive is open to question as a result of being excluded from missile defence. Whether Sapphire is sufficient to offset the missile defence decision remains to be seen. Nonetheless, as intimated in the 1998 *Space Policy*, Canada may well have to invest more to keep access fully open. One step forward would be full commitment to a Radarsat constellation.

Third, Canada's policy on the non-weaponization of space also acts as a psychological obstacle to defence space initiatives and investment. As space is the ultimate home of dual-use assets, as witnessed by the significance of commercial satellite capabilities for military operations, for example, any defence space initiative has to pass the weaponization test, which now also includes the missile defence test. This test is problematic, given that the definition of weaponization is still open to debate. Foreign Affairs' definition of weaponization may be relatively clear (weapons on orbit). However, it remains contested politically, as is evident when the missile defence debate in Canada erroneously became a debate about weapons in space. For DND and the CF, any space initiative confronts this possible outcome, thereby creating a reluctance to act.

Finally, DND and the CF are not the lead actors in Canadian space. For all intents and purposes, this role resides with CSA, and this creates a follower mentality, as well as a desire to piggy-back defence space requirements on CSA initiatives and funding. Furthermore, there is no up-to-date formal, national space policy to guide defence decisions on space. While one might suggest that DND and the CF are only really constrained by the all-party, national consensus on non-weaponization, bureaucracies are generally reluctant to step into the unknown.

Ironically, the current state of military space in DND and the CF may not be entirely negative. It is exactly those developments of the second space age, principally operational military space, that carry the very conditions driving the next military space age; an age when space becomes a truly independent military environment, similar in status to, but distinct in nature from, the current domains of land, sea, and air. Having lagged behind in operational military space, perhaps DND and the CF should start to pay more attention to the next age.

The Future of Defence and Military Space

Space is already a nascent theatre of war, even though the absence of weapons in space has led to a contrary belief. No weapons have been deployed from space to strike at targets on the ground. Yet there is a fine line in operational military space between enhancement and application. Space-based intelligence and communications provide reconnaissance and target identification. Satellites are now used to fly unmanned aerial vehicles (UAVs), and some UAVs are now combat capable (UCAVs). The Global Positioning System (GPS) guides precision munitions to targets.

It is not just the military dynamic, including the growing use of commercial satellites for military purposes, which will drive space into the next age. As space becomes more and more significant to national and global economies, states will be driven to threaten commercial satellites and the information derived from them as a means to threaten or strike at those national and global economies.

These factors suggest that the strategic deterrent and operational military space functions will merge into a single, distinct military area of operations (AO) (fig. 3.4). As space supports operations below, so will land, sea, and air assets support operations above. And just as operations are conducted on land, sea, and air, so will operations be conducted in space.

At the heart of the argument that military space is about to enter its third age are potential adversarial responses to operational military space. As a force multiplier for Western/American military forces that have hitherto been immune from direct attack, potential adversaries cannot help but consider a range of options to counter this multiplier. As a result, Western/American military forces will have little choice but to consider how to protect this multiplier from hostile attacks. The net result is to recognize that space and space-based assets will become fully integrated into conflicts as are the other domains of warfare. For most countries, this is encapsulated within the weaponization of space issue, which as discussed below, is definitionally and operationally complicated owing to the legacy of military space categories and concepts inherited from the first age of strategic deterrence space.

First of all, space is already weaponized for all intents and purposes, even though the definition of space was constructed to legally and conceptually separate missiles from space. The space age began with ballistic missiles (rockets) transiting through space to targets on earth (e.g., the German V-2). In addition, missiles (rockets) provide the means to access space, and the basic ability to place a satellite in orbit is essentially no different from targeting satellites on orbit, albeit somewhat more demanding technically. Today, no state formally possesses a ground-based ASAT.

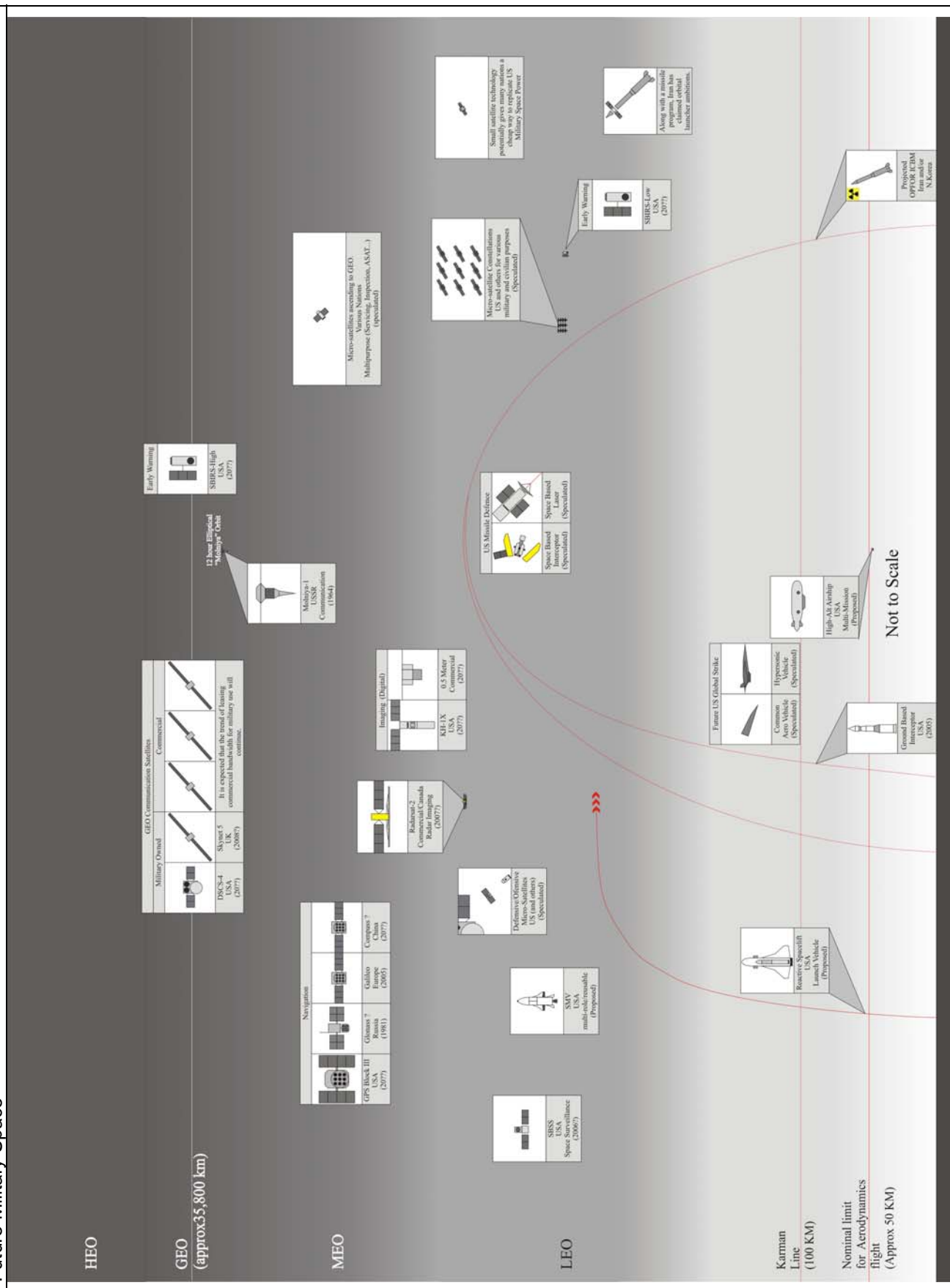
Nonetheless, the United States did possess an operational, air-launched, kinetic-kill ASAT, now retired, and its ground-based missile defence interceptor capable of intercepting a warhead during its mid-course phase is likely to be able to target a satellite in a predictable low earth orbit. The Soviet Union undertook several tests of a co-orbital chaser killer satellite during the 1970s and 1980s. Most recently, the Chinese demonstrated that capability by destroying one of its own satellites on orbit at an altitude of 530 miles (Covault 2007).

The proliferation of ballistic missiles and rocketry, despite the efforts of the international community through national export controls and the *Missile Technology Control Regime* (Harvey 2005), provides more states with the rudimentary capability to threaten space, and this reality can only grow. Similarly, more states have satellites in space than ever before. Satellites can threaten other satellites simply by virtue of their orbital location as space mines, for example, among other techniques. As satellite technology continues to evolve and diffuse, the inherent dual-use nature of satellites provides many different military options for war in space, even without the actual destruction of another satellite through a collision.

Finally, nations can already disrupt the information provided from or through space using a variety of electronic measures. They can also defend this information through a variety of electronic counter-measures. Similarly, satellites themselves may be able to disrupt or block signals of other satellites simply by their location within an orbit and/or constellation, such as when Indonesia's Palapa B1 satellite directly jammed another during a dispute over an orbital slot. Today, no one considers such activities as an act of war, and no one would question these actions in a state of war. Also, no one would question the military legitimacy of striking at a ground station.

It is now much easier and more cost effective to employ electronic measures to strike at the information itself, not to mention the fact that ground stations are vulnerable to attack. It is simply an extension of electronic and counter-electronic warfare designed in the case of space to disrupt or defend the space lines of information (SLOI). With regard to ground station vulnerability, for example, satellite cross-links in a constellation will reduce SLOI vulnerability by eliminating reliance on forward-deployed ground stations. Sending information across a constellation and then to a secure national ground station eliminates the vulnerability of using multiple ground stations and a series of down-up links from space to ground to space.

Figure 3.4
Future Military Space



These elements of modern space warfare are viable in part because of the existing dependence of states on civil/commercial space. In contrast to dedicated military satellites whose signals are protected against jamming, spoofing, and other electronic measures, commercial satellites are extremely vulnerable. Even the United States is increasingly dependent upon commercial satellites, which account for approximately 80 per cent of its military use of space.

Growing global demand, including military demand, ensures that civil/commercial satellites will continue to dominate military space. Most states simply cannot afford a sufficient number of dedicated military satellites and constellations to meet all their needs, even with declining costs. However, like the United States and the former Soviet Union who invested in key strategic, space-based assets during the Cold War, states are likely to be driven to identify similar key strategic assets that can be protected against most, if not all, electronic interdiction measures. Furthermore, attempts are already underway in the United States to convince the commercial sector to take some defensive actions (notwithstanding the measures taken to protect their signals today from piracy).

As the viability of electronic and counter-electronic measures evolves relative to the significance of operational military space, states will no doubt consider other methods to disrupt, and if in need be, destroy space. Attacking satellites directly is a difficult task, even with predictable orbits. Only a few states currently possess the ability to place objects in any and all orbits around the earth and potentially threaten militarily and economically useful space. Even fewer states possess the ability to track and identify objects in space. Only the United States possesses a global SSN, and even with that network, it is unable to track and account for all space activities. Further, despite the best efforts of the international community to promote transparency in payloads, no one knows the actual capabilities of all on-orbit payloads.

All objects in space are moving at high speeds that require precise calculations to intercept a satellite, park space mines close enough to damage an object, or manoeuvre within or through orbits to target a satellite (still problematic with energy availability in space at a relative premium). Precision is also essential to ensure the actual target is destroyed and collateral damage is limited, whether it is done by an on-orbit satellite chaser or by an interceptor. Even with precision, the costs of interception can be too high. A destroyed satellite will leave a debris field, potentially corrupting the orbit for a long period of time as well as damaging other satellites. Even if the objective is to push the satellite into a dysfunctional orbit, this may have serious consequences for one's own use of an orbit.

Moreover, the problem of precision is compounded by the vacuum of space. Conventional explosions are limited because of the absence of oxygen. Certainly an internal explosion can send objects (like a shotgun) outward for kinetic effect. Controlling their path to engage a satellite is very difficult. The direct targeting of a satellite with a kinetic warhead launched by a land, sea, or air-based missile is another possibility. As noted above, the United States successfully tested an air-launched system employing an F-15 capable of striking into low earth orbit in the 1980s.

Directed energy weapons and lasers are also generally seen as likely ASAT candidates. They resolve the debris problem by simply rendering a satellite operationally dead, for example, by blinding it. The United States, for instance, tested the mid-infrared chemical laser (MIRCL) against a satellite target in 1997 with apparently dramatic results. However, that success has not been followed up with a well-funded, major development program (and despite some reports, the United States' missile defence airborne laser is not a testing platform for a space-based laser). Most recently, China also demonstrated a nascent capability by illuminating an American spy satellite with a laser (Minnick 2007).

The technological complexity of precision interception, whether based on a platform in space or not, leads one to consider the effectiveness of nuclear weapons. Like a conventional explosion, the vacuum of space limits the direct damage a nuclear detonation can do. Unlike a conventional explosion, both the X and gamma rays and electro-magnetic pulse can render

satellites useless, but their indiscriminate impact is also much greater as their effects linger for a long period of time in space.

In a major test in 1962, Operation Starfish Prime, the United States detonated a 1.4 megaton warhead at an altitude of 248 miles over the Pacific Ocean (Stares 1985b). It caused a communications blackout and permanently damaged three satellites. The results were a significant factor in the negotiation of the *Limited Nuclear Test Ban Treaty* (1963) prohibiting the testing of nuclear weapons in space.

As in all military activities, action breeds reaction. Offensive developments are met with defensive responses. Satellites can be hardened against the effects of a nuclear detonation. With proper warning, they can be shielded against directed energy effects. Satellites may also be able to perform manoeuvres against kinetic attacks. States can also employ deception techniques to avoid tracking and targeting. Redundant satellites can be used as part of the system or constellation, or the requisite capability may be transferred to another satellite system in a different orbit. Satellites may also be stored on earth and launched quickly to reconstitute a lost capability.

Active defence measures may include the employment of defender or sentinel satellites on orbit. Boost-phase ballistic missile defences, whether space-based or not, can intercept ASAT missiles by destroying them during their most vulnerable phase, which is from launch until they exit the atmosphere. In this case, boost-phase serves both defence and denial purposes; defending satellites from attack and denying an adversary's access to space.

Today, the technology for space-based, boost-phase intercepts remains in the future. The costs are also highly prohibitive as a large constellation would be needed. In a recent Congressional Budget Office report (2001), a space-based system would cost between US\$27.1 and US\$77.8 billion to develop, deploy, and operate for twenty years. Above all else, the complex strategic, operational, and political implications of such a development have yet to be clearly delineated. Of note, the United States' Missile Defense Agency announced a plan to launch a space-based interceptor test bed in 2008 (Missile Defense Agency 2004). This plan has now been significantly scaled back (Missile Defense Agency 2007).

The relatively indiscriminate nature of any physical attack on satellites, whether a crude nuclear attack or a precise kinetic-kill, suggests that every nation employing space for military, civil, or commercial benefit will be at risk. With most states enmeshed in a global economy with space as a central enabler or component, everyone has an interest in preserving space as a sanctuary from attack, which necessarily also extends into a common interest against using and deploying weapons there.

This is the new deterrent argument, somewhat different from that which informed nuclear deterrence during the Cold War. As all will lose if space is attacked, then none will threaten or attack. Moreover, this recognition should then lead states to forego the option of developing such weapons, and a common interest in protecting space should readily lead to codification in international law. Moreover, the dominant first-order, space-faring nations, especially the United States, also have the most to lose if space is attacked, and the most to gain from declaring space a sanctuary (DeBlois 1998). They also have the capacity to undertake most, if not all, passive defensive measures outlined above, and are also developing new measures and tactics. This capacity provides a significant hedge against the effects of cheating and/or the failure of any agreement in the case of war.

Not all states, however, would decide that the costs of a physical attack would outweigh the benefits in all circumstances. Even if such an attack stood little chance of damaging protected military satellites, it could significantly affect civil and commercial space, which could have an even wider, more devastating economic impact. For example, the 1997 United States' winter war game saw the red team attack space employing nuclear weapons which then led to a predicted worldwide depression lasting twenty years (Lockwood 2000).

Civil/commercial space is an inviting, vulnerable target. Like its naval counterpart, the Merchant Marine, commercial targets have wider military and economic significance. It is exactly the indiscriminate nature of a crude nuclear attack, for example, on civil/commercial space that makes it a potentially attractive and available option.

Weak states less dependent upon space services stand to lose much less from disrupting space than do the strong states. It may be the only means to strike back and affect an adversary's national homeland. It can be undertaken without fear of nuclear retaliation. It is a deterrent threat which can alter the cost-calculus for intervention by the strong into local/regional conflict. In particular, threatening civil/commercial space is a classic denial or asymmetric strategy for the weak, little different than the German U-Boat strategy in both World Wars. Threaten space to deter intervention, deny space to prosecute war, and destroy space to damage your adversary's capacity and their will to wage war.

With the crude capacity to do so within reach of many states as a function of proliferation, one is driven to offset this strategy by defending and foreclosing physical access to assets in space; no different from attempting to prevent German U-Boats (and surface raiders in World War II) from gaining access to the high seas by controlling certain choke points and physically defending the merchant marine by using convoys and arming their vessels. Boost phase intercept and guardian sentinel satellites, for example, are the future equivalent of bombing shipyards, controlling transit channels, and armed escorts. Both seek to control a military environment in order to deny an adversary's use and to defend one's own use.

For the dominant first-order, space-faring power, the United States, which happens to also be the dominant naval (and overall military) power, the logic driving naval superiority and command of the seas is similar to the drive for space superiority and command of the heavens. As the United States, in conjunction with allies, defends the sea lines of communication, supporting freedom of passage on the high seas, so the United States with its allies can serve the same function of defending the SLOI and supporting freedom of passage on orbit.

Of course, the high seas metaphor is only partially useful to understand the uniqueness of space as a military AO. Space has attributes that the high seas do not possess. It is at the same time the ultimate high ground as understood in traditional army thinking. Future multi-spectral, remote observation sensors will make it nearly impossible to hide anywhere below. Three dimensional mapping of the earth married to sophisticated simulation capabilities provide a dramatic advantage in training, operational planning and preparation, and execution.

The high speeds of satellites in low earth orbit and future sub-orbital platforms (space planes) can give states an unprecedented strategic advantage. These advantages speak to air force strategic thought as well; the original argument that underpinned the case for an independent air force (MacIsaac 1986). For now, technological limitations remain a significant barrier, especially with respect to propulsion. Once a breakthrough occurs, the ability to manoeuvre in space and project power very rapidly over long distances (beyond the current state of ballistic missile technology) will fundamentally alter the strategic military world. It will simply reinforce the reality of space as a separate and unique military environment that contains attributes of the other military environments, but is more than simply the sum of those parts. It will demand its own strategic thought, and very likely, its own military service.

Preparations and thinking about this new environment have been underway for some time. In the United States, it began in 1982 with the establishment of the United States' Space Command and the three space service commands. In 2002, Space Command was merged with Strategic Command, a process recently followed by the establishment of two subordinate functional, joint-component commands (Global Strike and Space). Military space itself (the flying of satellites) remains the responsibility of the United States Air Force, and more specifically, USAF Space Command and the 14th Air Force. More importantly, the USAF has begun to speak of itself as a space and air force, even though it has dropped the concept of aerospace (Smith 1998). In

addition, National Security Space has been established within the Pentagon as the central agency dealing with a range of space security issues, including policy planning, and it is arguably the foundation for a new organization within the Department of Defense and perhaps a separate service entirely in the future.

It is difficult to predict how organizational responsibility for military space will evolve. But it is evident that organizational evolution will be the clearest indicator of how space strategic thought develops. For now, a strategic, independent vision of space that integrates the strategic, operational, political, and technological considerations exists only in embryonic form (for examples, see Oberg 1999; Lambakis 2001; Dolman 2002; and Lambeth 2003).

It is critical that allies influence this development. The division of Strategic Command into Global Strike and Space provides an opportunity for allies to engage in the latter without engaging in the more politically problematic former, which includes nuclear weapons and is likely designed to be American only. However, this may yet be problematic, especially if a holistic view of military space confronts the political weaponization barrier. In the future, the division between politically acceptable militarized space (all military uses except weapons in space, and ostensibly, the targeting of satellites in space) and unacceptable weaponized space will become unsustainable even in the absence of the actual deployment of weapons on orbit.

For Canada which has long attempted to balance its military interests in space and its policy of non-weaponization, space as an independent AO is problematic. Canada's strategy of reliance upon the United States, limited investment to ensure access, and the promotion of a legal regime prohibiting weaponization may no longer be viable. During the Cold War, Canada's commitment to nuclear disarmament could co-exist with NORAD's early warning role for the United States' strategic deterrent. In the future, Canada's non-weaponization policy may well undermine its access strategy as the line between militarization and weaponization blurs.

Certainly, Canada can continue as it has and largely ignore space as an emerging independent military domain. In the same way that strategic nuclear deterrence was kept at arm's length, so perhaps can the military space domain. Canada will simply avoid any capabilities or investments that could be linked to space as an independent warfare environment. Whatever space-based threats to Canadian security emerge will, by default, be the responsibility of the United States. In fact, Canada has already moved down this well worn path. The defence of Canada against missiles is the responsibility of the United States, as the Martin government rejected any Canadian involvement in ballistic missile defence.

In the end, looking is fine, but acting is not. The same may be said about space itself. Looking into space is fine, but acting upon the information is up to the United States. This is the essence of Canada's only dedicated military satellite project, Sapphire. At slightly less than \$C100 million, Sapphire is a single optical satellite to be launched into low earth orbit to observe the outer orbits, especially geosynchronous orbits. It will become the second space-based sensor for the SSN, assuming it flies before the United States Pathfinder Satellite in 2008.

Initially, Sapphire was seen partially as Canada's asymmetric contribution to North American ballistic missile defence, consistent with the 1994 *White Paper* suggestion of a Canadian role (Govt. of Canada 1994). It is defined as a replacement for the Baker-Nunn cameras that were retired in 1992 and will represent Canada's only asset commitment to the space side of the NORAD aerospace mission since the decision was made to reject participation early in 2005. Sapphire also meets DND's 1998 *Space Policy* commitment to "monitor activities in space in areas of national interest" in order "to protect national interests from threats located in or passing through space" (DND 1998, 3).

Of course, Sapphire will only provide a small picture itself. The key is to obtain access to the full picture and prevent any further marginalization of Canada and NORAD as a function of the missile defence decision. Even with the most advanced SSN in the world, the United States

cannot track and determine the purpose and intent of everything in space, especially with over 9,000 objects circling the earth. Even with the network, the United States may not be able to judge what has happened to a satellite that suddenly “goes dead,” as was the case of the Galaxy-4 satellite in 1998. Thus, anything that adds capability is significant by default.

However, American policy is very clear about dependency, even on its closest allies. The United States will maintain essential national capabilities. In this regard, the United States’ program to develop a Space Based Space Surveillance (SBSS) system, beginning with the planned 2008 launch of Pathfinder, is indicative. Sapphire may be useful and important, but it is not potentially crucial. Furthermore, Sapphire only gives Canada a small glimpse into space. It does not, by itself, lead the United States to disclose a range of significant information regarding activity in space, unless it is willing to do so. Dependency remains.

But it is not just a question of dependency. During the Cold War, Sapphire would have kept Canada’s distance in the strategic world of nuclear deterrence. In the future, an optical sensor also serves to provide other valuable military information with regard to space, including the potential tracking of warheads and the targeting of satellites. In so doing, it also becomes a target, and as a target, it requires defensive measures. Moreover, if Sapphire cannot be integrated into future military options owing to the non-weaponization policy, then its utility to the United States in the future will be relatively low. As a result, the strategic payoff to Canada will likely be highly limited.

Sapphire does speak to the blurring of strategic military space as deterrence and strategic military space as warfighting. Strategic and political utility will require an understanding of this new space age in order to inform investments. This does not mean that Canada has to move itself into the weapons side of the equation. But it does mean that Canada has to come to grips with this new strategic environment. This will be difficult, however, as was evident in the recent missile defence debate. A ground-based system became synonymous with weapons in space. As a result, any serious discussion of the military future of space is problematic for any Canadian government. Every project must pass the “weapons in space” test, and the developments underway with regard to space may well mean that few will pass that public test.

With investment thus politically constrained, Canada’s ability to influence wider diplomatic developments with regard to space is similarly limited. Canada might fully abandon its drive for an international treaty prohibiting weapons in space in the Conference on Disarmament in favour of its new space security strategy of taking small steps to develop a more effective space regime (for example, see Department of Foreign Affairs 2004). The logic of this strategy is impeccable, whether for regulatory (avoiding accidents) or transparency and confidence-building (arms control) reasons.

However, Foreign Affairs’ interest in the arms control side of the equation versus the American concern for the regulatory side is problematic. The United States will be suspicious of Canada’s motives. This, along with the lack of investment and the absence of a truly independent space capability and commitment to space, will continue to handicap Canadian influence. As such, Canada is likely, for example, to have little input in the forthcoming debate on the definition of space. As new technologies enable states to exploit sub-orbital space, the legal definition of where space begins (international) and air ends (national) becomes a major issue. This, of course, has implications for Canadian sovereignty and national security. As in the direct relationship with the United States, dependency provides little means to influence outcomes. Canada remains vulnerable to the dictates of others.

Conclusion and Recommendations

For Canada, DND, and the CF, it is difficult to discern where the nation plans to go in military space. Different from most, if not all, other non-major powers, Canada has historically maintained

a foot in the door of strategic space with its unique relationship with the United States through NORAD. It kept America's nuclear strike forces at arms-length. Since then, a certain logic driven by interoperability pushes Canada down the operational military support line. Non-weaponization dictates the avoidance of military space as an independent defence and security domain.

Overall, though, there is a remarkable consistency in a strategy developed in a world of the past. All that really matters is access to the information or data that can be derived from satellites. All that is needed is limited investment to leverage such access from the United States or to purchase it commercially. Most importantly, military space is the responsibility of the United States. The Department of National Defence and the CF, and thus the government and Canada, have accepted a condition of dependency upon the United States, and of course, any such level of dependency creates significant vulnerabilities. Simply put, DND and the CF are not in space, and even the one planned military satellite, Project Sapphire, will do little to alter this reality. The security of Canada and space is its ally's job, and this will likely increase in the future as new developments and new technologies lead to the next era of military space, an era that DND is currently unprepared to examine, let alone prepare for.

Perhaps Polar Epsilon and the Space Systems Support projects are harbingers of more attention and greater investment. If so, then perhaps Canada's defence and military space strategy can be functionally sustained, even with the non-weaponization barrier. However, **Canada remains dangerously vulnerable as a function of its one-sided military space dependency with the United States and of the absence of a current and viable long-term military space policy and strategy.** If Canada fails to appreciate and respond to the changes that are occurring in defence and military space, it will become further marginalized as the United States moves forward and as Canada remains trapped in the past by its non-weaponization policy.

Recommendations include:

- **Canada adopt a more regulatory approach to space security and weaponization, so it will have more influence over today's unfolding global space realities;**
- **Department of National Defence renew its space policy and strategy; and**
- **Department of National Defence commit fully to Project Epsilon II.**

CHAPTER 4

CANADA, NATIONAL SECURITY AND SPACE ECONOMICS

Introduction

A core component of national security is the concept of the well-being of the nation and its citizens. Although well-being may take many different forms, it is largely, though not exclusively, linked to economic considerations, such as generating wealth and providing a reasonable standard of living for a nation's population. Threats to the economy therefore represent threats to the nation. As noted by many observers, a significant economic downturn or disaster can generate levels of public dissatisfaction that may lead to internal unrest, and in extreme situations, revolution and/or rebellion. While most members of stable, advanced democracies like Canada's tend to discount the likelihood of internal unrest as a function of an economic downturn and generally take their economic well-being for granted, given the normal ebb and flow of any economy, governments remain acutely attuned to the vulnerabilities of the national economy.

This vulnerability takes two forms relative to national security. The first concerns the ability of the economy to continue to generate wealth within a global economy by remaining competitive and continuing to develop even as technology and the nature of wealth generation changes. The most recent example is the ongoing shift from an industrial to an information-based service economy.

The second are the vulnerabilities associated with a natural or human-made disruption, currently captured by the idea of critical economic infrastructure, the loss of which would significantly affect economic performance. Both of these vulnerabilities exist with respect to space as it is evaluated below; the former concerns the space industry and the associated industries and technologies which enable the exploitation of space for economic purposes – a process that will continue to grow in significance for wealth generation and international competitiveness – while the latter relates to the increasing importance of space services to a nation like Canada and to its economy, hence the recognition that space infrastructure is a critical component of the nation's overall economic health.

Today's global domestic product is upwards of C\$40 trillion, an unprecedented level of productivity (Economist 2005, 26). It is the result of the development, employment, and interweaving of a host of energy, material, and particularly information technologies within a complex socio-economic, global milieu, a milieu centered around, and driven by, the world's most advanced and productive nations – the G8, of which Canada is a member. The G8 accounts for three-quarters of the planet's productivity and consumption, which are information rich, information dependent, and information vulnerable. Information underpins today's modern economies, and the collection, creation, and dissemination of information is what space is all about.

Within this global economy, world space activity exceeds C\$110 billion per year; about 1/4 of 1 per cent of the world's GDP (ISBC 2005). **On the surface, it is dwarfed by the likes of the telecommunication and auto industries. Nonetheless, space is indispensable to the smooth functioning of today's most modern and advanced economies. Space services include accurate environmental prediction, worldwide connection, worldwide synchronization, and worldwide just-in-time and just-enough-movement of information upon which those larger economies depend.** From providing daily weather information to underpinning modern global movement, the presence of space is felt in one way or another across almost every economic sector.

The 700-odd active, on-orbit satellites and payloads are significant to the world's economy far beyond their direct economic valuation, and this is particularly true for Canada. Space is a critical infrastructure component given that Canada's advanced economy operates across a huge geographical area that has a relatively small and dispersed population. While much effort has

gone into identifying the nation's security concerns and interests since 9/11, Canada's existing and steadily growing dependence upon space-based systems has garnered little to no recognition. Little attention has been paid to how much of today's space reality is controlled by others, nor to how vulnerable it is to physical, electro-magnetic, fiscal, and political disruption. Neither has the place of space within Canada's national economic priorities been addressed, especially with Canada falling behind the other G8 nations (Athena Global Report 2006).

Currently, space manufacturing and operations in Canada accounts for only about 0.2 per cent of its GDP, but space use is felt across a very wide swath of its economy (table 4.7). Canada has successfully leveraged its limited niche space investments over the last forty-five years to gain user access to a host of space-based services on which it now depends. However, it has little, and at times no, control over, or influence upon, these services. This reality is especially surprising when one considers that Canada was a very early space pioneer. It is also one of the world's largest aircraft manufacturers; the technology arena that spawned, and remains akin to, today's space community.

Canada's lack of space investment and high external space dependence is even more surprising from a sovereignty perspective when one considers its historical concern over freedom of both choice and action, particularly when it comes to its relationship with its southern neighbour. The United States is the world's largest space player and Canada's most generous space service provider. **Overall, Canada has a small, end-user biased, space-manufacturing capability; little national interest in, or commitment to, space operations, and little understanding of the critical role that space plays in its economy.**

Canada and the Space Industry

The global space industry consists of a very specialized and skilled community of space support services (for example, educators, financiers, and consultants) and space systems development and manufacturing firms. This community exists, for the most part, within the world's larger aerospace manufacturing industry, worth around C\$400 billion in annual revenue. Space constitutes approximately 10 per cent of the global aerospace industry at about C\$40 billion (table 4.1). Much of that industry is often more recognizable as aircraft manufacturers. The space industry also resides almost exclusively within those nations that support and fund space activity. These nations tend to protect and nurture the space industry highly.

Table 4.1 Global Space Industry \$CMillions (International Space Business Council, 2005)		
Industry	2005	2010
Support Industry	3,265	3,071
Launch Industry	5,485	6,604
Satellite Industry	22,089	29,400
Ground/End-user Industry	11,749	15,084
Total	42,588	54,159

Everything is made possible downstream for space operators and final end-users by the size, vitality, and financial well-being of the space industry. The industry consists of four

segments: launch manufacturers, satellite and payload manufacturers, end-user and ground component manufacturers, and the space services industry. Virtually all of the space industry's related aspects are intensive in nature, whether we consider its capital/finances, innovation, skills, and/or processes.

For a variety of reasons dating back to the late 1960s, Canada largely chose to limit its investment to select space satellite and payload niches instead of seeking to develop and sustain a vibrant national space industry across all the components noted in the last paragraph, as well as within the space satellite and payload component as a whole. In comparison to the other G8 members, Canada has a very limited space manufacturing capability. The industry is largely contained in three firms (MacDonald Dettwiler and Associates [MDA], Com Dev, and Bristol Aerospace). It is end-user and ground-segment biased, and it seeks investment and work predominately outside the country. At C\$1.1 billion in annual sales, the industry appears to be relatively healthy and successful on the surface (Canadian Space Agency 2005). On closer examination, however, it exhibits numerous weaknesses as a function of the way its activities are skewed towards end-users, its overall low levels of investment in research and development, and the long periods between national initiatives.

Globally, government funded programs are indispensable to the health and competitiveness of individual national space industries. Government procurement of space systems is by far the largest source of revenue for space manufacturers. It provided about 90 per cent of the industry's revenues in 2004 (Euroconsult 2005). Illustrative of the state of space investment, the Canadian space industry derives only 10 per cent of its revenues from Canadian government contracts, a figure that is even smaller than it was five years ago. Moreover, the other members of the G8 have markedly increased their space industry investment over the same period.

Parallel to the importance of government investment, a vibrant industry needs readily accessible space education, finance, design, and production expertise. Space systems' development starts with the institutions that hold, teach, and promulgate humanity's space flight knowledge, followed closely by institutions that can finance and assume risk for the development and deployment of space systems. These are the space support services industry. However, that industry has little presence in Canada. Outside of a small space science program at Canada's Royal Military College, space education resides weakly only within the larger disciplines of astronomy, physics, and engineering in a few of Canada's other campuses. **Likewise, one also finds an absence of private firms in Canada dedicated to training, consulting, publishing, legal issues, and finance as related to the space industry.**

Building upon space support services, space utilization depends upon space access: the launch manufacturer industry. The global rocket industry is worth C\$5 billion and resides in the world's first-order, space-faring nations: the United States, Russia, France/European Union, Japan, China, India, and Israel. It supports sixty to seventy space launches per year, with the average launch vehicle costing between C\$25 and C\$125 million. Not surprisingly, it is dominated by the United States, with Russian/Ukrainian production running second. Contracts for government launches, which generally go to a nation's own domestic manufacturers, account for 75 per cent of all launches (ISBC 2005). Within this industry, Canada has no presence save Magellan (Bristol) Aerospace's 1960s-era, sub-orbital Black Brant rocket.

Launch demand has been soft over the last half dozen years. It now appears to be strengthening with some new industry entrants. For example, the United States-based SpaceX has been aggressively promoting a low cost, partly-reusable launch option. SpaceX, like most new entrants, entered the market by focusing on the low earth orbit launch segment and offering significantly lower prices than the industry's major players.

The satellite and payload industry encompasses the research, development, manufacturing, and testing of satellites, spacecraft, and robotic systems, along with their subsystems and components. Satellite manufacturers provide satellites to three primary markets; civil (government space

agencies), military, and commercial. A fourth, smaller niche market also services the world's academic community, which accounts for the largest number of Canadian launches in a year.

The global industry generates approximately C\$22 billion in revenue from an average worldwide production of 80 spacecraft per year, or about 1.5 per week. In 2004, 76 payloads were launched into orbit, with 17 for commercial purposes and 59 for government, scientific, or non-profit purposes (ISBC 2005, 32). Like the launch industry, the civil and military segments are the largest, most lucrative, and most protected. Commercial satellite production only accounts for 20 per cent of the industry's unit numbers, although each unit is likely destined for a geostationary orbit and is worth C\$150 to C\$200 million each (Teal Group Corporation 2006).

The satellite industry is made up of a large number of manufacturers worldwide. However, the industry is dominated in revenue generation by five companies: Boeing Satellite Systems and Lockheed Martin in the United States; Alcatel, Alenia Space, and European Aerospace and Defence System's Astrium in Europe; and Mitsubishi Electric in Japan. Alongside these major companies, satellite activity continues to grow in China and India, and there has been a resurgence of Russian activity as well.

Table 4.2 Canadian Space Manufacturing Revenues C\$Millions (CSA, 2005)		
Year	Satellite/Payload Industry	Ground/End-User Industry
2000	602	229
2001	467	386
2002	445	338
2003	297	471
2004	553	572

Despite complete foreign dependence in the launch to orbit sector, Canada's industry does have a recognizable presence in the world's space satellite and payload industry. Its annual sales currently exceed C\$500 million, or about 2 per cent of the global space segment market (table 4.2). The primary firms involved in satellite and payload manufacturing are the three large firms discussed above. Bristol Aerospace in Winnipeg (a company of the Magellan Aerospace Corporation) concentrates on scientific payload and small satellite design and production. Bristol was the

prime contractor for the design and development of Canada's first small satellite since 1971, the CISAT-1. It was built for the Canadian Space Agency (CSA) and launched in August 2003. Com Dev is a spacecraft transponder design and manufacturing company in Cambridge, Ontario. Com Dev was born of Canada's early satellite initiatives of the 1960s and is a world leader in transponders. Finally, MDA has space robotic and satellite integration activities in the former SPAR Aerospace facilities in Toronto and Montreal.

Canada's technological and corporate presence increases as we move away from the satellite and payload manufacturing industry and begin to consider the terrestrial interface between satellites and users. The farther we get from the initial facilitating or space access technologies and the closer we get to end-user technologies, the greater Canada's industrial presence becomes. From large earth stations and satellite television dishes to GPS receivers, the end-user and ground segment contains a diversity of hardware, software, and electronic firms that enable operators and users on the ground to receive, control, process, and disseminate space-generated or space-transmitted information. This industry segment also includes the research, development, manufacturing, testing, and integration of terrestrial systems that are used to control space-based systems and satellites, to link satellites to operational terrestrial users, and to process satellite-derived data.

Within this realm, Canadian industry enjoys 5 per cent (C\$600M) of the global C\$12 billion market (table 3.2). The most notable national firm involved in this market is MDA, headquartered in Richmond, British Columbia. Its expertise and products are deeply rooted in remote sensing. Exploiting its ground and end-user expertise, MDA, in a unique public/private partnership (PPP) with the CSA, is also the owner and operator of the soon to be launched Radarsat II (the follow-up to

Radarsat I), as well as the prime contractor and operator of Canada's first military satellite, the Sapphire, a space-based, optical, space surveillance satellite planned for launch in the near future.

Overall, at C\$1.1 billion per year, Canada's space manufacturing industry represents 3 per cent of the global industry. Its industry is skewed towards end-users and sub-components, although a satellite test and integration capability does exist, as does a small satellite and sub-orbital rocket capability. These capabilities are relatively fragile, however. Unlike other national space industries around the world, Canada's space development and manufacturing industry relies almost exclusively upon commercial and international sales. While government proclaims the success of the industry because of this bias towards commercial and international sales, it was not necessarily the product of a focused, national space policy. Instead, it has resulted more from the relative absence of high-level government concern, particularly over the last fifteen years.

While the CSA developed a variety of small industry programs to encourage technological development, including the recent announcement of a C\$10.3 million investment in thirty-six research and development projects involving new space technologies and applications (*Defense Industry Daily* 2007), Canada does not measurably invest in or buy Canadian. For example, in the case of Radarsat II, neither the satellite nor the launch vehicle is Canadian. Similarly, DND has a 1998 *Space Policy* that argues the need for a greater national space capability, yet it consistently procures this capability offshore, in one way or another. DND's current surveillance-of-space initiative, Sapphire, is a case in point. It is scheduled to be built offshore.

Canada's G8 allies and economic competitors use national space requirements and initiatives to provide stable baseline and research and development funding for their industries. They do so with the knowledge that the cost of not being in space is too high to ignore. It is currently too high with respect to forsaking a role in the development and management of space. It is too high in the near future with respect to lost industrial and economic opportunities, and too high in the long term sovereignty and security implications of forsaking the use and control of the domain to others (and thus to their agendas). For the time being, commercial space alone does not permit the growth of a vibrant industry. The most commercially valuable and the most difficult to replace services (weather and earth observation, and global spatial and temporal positioning) are freely provided, for the most part, by the most dominant first-order, space-faring nations. The dominant nation(s) give these services away not just on humanitarian and good will grounds, but also to retain control over them, and over the domain itself.

Canada and the Space Operators

Downstream from the space manufacturers are the space operators and agencies. While they are dependent on the manufacturers to produce the systems, **the space operators and agencies ultimately control the global space agenda through their understanding and use of space, through their programs and budgets, and through their public lobbying and private initiatives.** Space operators and agencies can be divided into three primary groups; civil, military, and commercial. This global group oversees budgets and revenues in excess of C\$110 billion. Forty per cent of this figure is redirected upstream to the manufacturing industry in the form of procurement and services contracts (ISBC 2005; Euroconsult 2005).

Largely devoid of any substantive military space capability, Canada's operational space expertise and assets reside in civil and commercial entities, and more specifically, in two such organizations, Telesat Canada and the CSA. Combined, they account for C\$1.3 billion of activity annually, though the overwhelming majority is connected to the former. Both are products of historical government intent. Telesat Canada, as a private entity, has prospered. The nation's space agency has fared less well, particularly of late. **Canada, in comparison to the other G8 members, has modest national interest in, or commitment to, space operations.** Canada stands out among the G8 as the only nation not to

have expanded its space investment over the last five years. In fact, it has actually decreased its funding to the CSA and space (Euroconsult 2005, 95).

From approximately 1957 to 1989, space development was almost exclusively led by the national agendas of the two Cold War superpowers, and it was almost exclusively managed by their respective civil and military space agencies. At the outset, space development was encouraged by both Soviet and American interest in ballistic missiles, and for the United States, the ability to safely over-fly the Soviet Union for intelligence purposes. Fuelled thereafter by ongoing security and prestige agendas, the two powers and their respective space organizations shared global dominance in space until the break-up of the Soviet Union. Over that period, the Soviet Union accounted for two-thirds of the global space launches, while the United States accounted for almost all the rest.

Table 4.3
Canadian Space
Applications and Services Revenues
C\$Millions
(CSA, 2005)

Year	Revenue/Budget
2000	584
2001	989
2002	981
2003	1,179
2004	1,271

In the wake of these two space vanguards, other nations also sought space access in far more modest terms. A group of second-tier space powers emerged, led by France, Japan, and China and more recently joined by India and Israel. All created civil or civil-military space organizations with national well-being, prestige, and security mandates. They all developed indigenous launch capabilities. Over the years, a spectrum of other nations like Canada also developed and deployed their own satellites and spacecraft. These actors relied upon foreign launch services or, as in the case of Western Europe, a multi-national launch provider through the European Space Agency (ESA). The ESA, created in 1980, was formed to provide Western Europe with an overarching and integrated regional space presence and capability. Championed by France, the ESA has also enjoyed significant German, British, and Italian support. Over the years, it has successfully developed the Ariane family of launch vehicles and sustained a sizable civil space program.

Outside the government realm, commercial space commenced early on with much government support and protection. Primarily focused on the provision of space-based communications, commercial space has progressively prospered and grown over the years. Today, commercial space operations are significant, even if space continues to be highly dependent on governments, particularly for systems development. Today's commercial space community represents over C\$60 billion in revenue per year, and comprises a worldwide spectrum of private and semi-private enterprises (table 4.4). In 1996, commercial revenues surpassed government expenditures for the first time in the history of space.

Table 4.4
Global Commercial Space-based Services
C\$Millions
(International Space Business Council, 2005)

Service	2005	2010
Fixed Satellite	7,940	10,691
Direct-to-Home	46,273	70,670
Mobile Satellite	772	1,022
DARS Radio	906	5,459
Broadband	127	1,478
Imagery	718	1,154
GIS/GEOINT	3,449	3,808
World Total	60,185	94,282

The commercial space industry is overwhelmingly dominated by, and focused on, providing a variety of long distance, mobile, and remote satellite communication services for a host of purposes to corporate clients and individual consumers. Communication services account for over 93 per cent of all commercial space revenues, with half of those revenues generated within the North American market (ISBC 2005). Composed of some forty firms, the satellite communications industry is dominated by Intelsat and PanAmSat, operated out of the United States, and Eutelsat, Inmarsat, and SES Global out of Europe. The remaining 7 per cent

(approximately C\$4B) of commercial space activity is generated from the sales of satellite imagery and geo-information services primarily to government and large corporate customers. Four commercial firms dominate the industry: the American firms – Space Imaging, Orbimage, and Digitalglobe – and the French firm, Spot Image.

Commercial space has fallen victim to a weak market over the last five years. Nonetheless, trends indicate growth in all services in the near future, and especially in the direct-to-home satellite radio and broadband communication markets. At the same time, the industry enjoys a growing number of private-public partnerships (PPP) as governments continue to seek better ways to provide and stimulate space-based services. Notwithstanding the growing commercial presence, public investment continues to be the dominant space development driver, particularly in the United States.

With the dissolution of the Soviet Union, the United States assumed sole leadership of the global space agenda through its civil and military programs. This dominance is now starting to be challenged by other first-order, space-faring nations. Nonetheless, the United States still dwarfs the combined space spending of the rest of the world. It spends approximately C\$38 billion on its national space programs, compared to Western Europe (C\$8B), Japan (C\$3B), Russia (C\$0.7B), and Canada (C\$0.3B) (Euroconsult 2005).

Combined, the world's civil and military space programs, after a decade of stalled growth through the 1990s, now account for over C\$50 billion in annual expenditures; the highest level of public expenditure so far, and one that is projected to increase by 15–20 per cent over the next four years (ISBC 2005). In terms of satellite launches for the next ten years, 40 per cent are forecast to be commercial, with government initiatives accounting for the rest: 44 per cent civil, 4 per cent university, and 16 per cent military (Teal Group Corporation 2006).

The civil space community is still dominated and led by the interests and policies of the United States and its principal civil space organization, NASA, which accounts for 60 per cent of the world's civil expenditures at C\$20 billion. Alongside ESA and the Japanese space agency (JAXA), they account for 95 per cent of the world's civil space expenditures (table 4.5). Russia's activity is growing, as is India's and China's, which have increased their space budgets by a factor of five over the last ten years and enjoy far lower operating costs than their Western counterparts. Some twenty-seven countries currently have dedicated civil space budgets exceeding C\$10 million (Euroconsult 2005).

NASA and the CSA in large measure stand alone with their space exploration and human spaceflight emphasis. Otherwise, the world's civil programs are becoming increasingly interested in the furtherance of space-based services; the development of communications, navigation, and of weather and earth observation capabilities. Excluding NASA, 44 per cent of the world's civil space budgets are allotted to space applications, compared to 33 per cent in 1990. Investment in space exploration over the same period has declined from 33 per cent to 27 per cent (Euroconsult 2005).

Table 4.5
Leading Civil Space Budgets
C\$Millions
(Euroconsult, 2005)

Country	2000	2004
USA	14,918	17,457
West Europe (ESA)	5,107	7,399
Japan	2,754	2,763
France	1,364	1,766
Italy	633	931
Canada	300	296
World Total	24,107	29,676

Table 4.6 Leading Military Space Budgets C\$Millions (Euroconsult, 2005)		
Country	2000	2004
USA	15,290	20,488
West Europe	695	1,008
France	355	542
UK	110	294
Russia	110	200
Canada	Nil	Nil
World Total	16,320	21,860

At C\$22 billion and growing at roughly 7 per cent per year since 2000, worldwide military space expenditure rivals civil expenditures (table 4.6). The global military space community is, however, significantly smaller than the civil one in terms of participants. Some thirteen nations invest in military space. Ninety-five per cent of that investment occurs in the United States. Western Europe, lead by France, invests C\$1 billion per year in military space, and Russia has begun to reinvest in its military capability. Military space investment remains controversial for many nations, but driven by modern battlefield information needs, military space investment and military space actors are most likely to continue to grow in the coming years.

Canada's space situation stands in sharp contrast to the overarching global state of affairs outlined above. Canada's commercial activity, primarily generated by Telesat Canada, far exceeds Canada's public investment and activity. In comparison to all the other countries active in space, Canada has the most export-oriented space industry at 50 per cent, as well as the most commercially dependent, at 80 per cent (CSA 2005). The internal actions of the CSA and the DND over the last fifteen years have expanded that contrast even more.

As the world has progressively sought to further space application investments, CSA has moved in the opposite direction (table 4.7). It has increasingly dedicated its scarce resources to space science and exploration. Concurrently, squeezed by budget freezes, it has reduced its procurement of space hardware by 40 per cent over the last seven years, while increasing its in-house personnel by 29 per cent. The Department of National Defence, for its part, began the 1990s with significant plans to invest in space for security and sovereignty reasons. In the end, it has done little, not least of all because of a series of budget cuts followed by the pressing need to rebuild and modernize the Canadian Forces, a need that continues. Arguably, DND has less space expertise and understanding today than it had fifteen years ago. This occurred during a period that saw extensive military space growth in the United States under the rubric of the revolution in military affairs and transformation.

Table 4.7 CSA Budget Allocations C\$Millions (Euroconsult, 2005)		
CSA Program	2000	2004
General Budget	32	34
Telecom	15	14
Earth Observation	91	61
Space Science	40	66
Technology	26	41
Human Spaceflight	80	57
Microgravity	17	23
ESA Contribution	17	23
Total	300	296

Today, Canada has some 7,000 individuals employed in space activities, but for the most part, not as a result of government and national intent. **The Canadian government has financially retreated from space over the last decade. Its last major capital project announcement (Radarsat II) dates back to the 1990s.** The Canadian Space Agency, at its current funding level, has little ability to initiate any major new program and even less to further the national space agenda. The country's space future currently rests more with Telesat Canada and the country's space applications and service industry, an industry driven by private return-on-investment demands rather than national sovereignty, security, or economic development interests. Moreover, these demands are increasingly being satisfied internationally.

Canada and Space Criticality

Concerns over Canada's limited space manufacturing and operational capability are arguably misplaced if space has no central bearing on the nation's economy as a whole. Unfortunately, this is not the case. Canada's advanced economy depends upon space assets and the services they provide. **The loss of space-based services would have a deep impact on the Canadian economy, far beyond what might be assumed from the comparatively small economic size of the space sector** described above. In fact, space assets play key roles in many of the broad areas or sectors identified as critical infrastructure by the Canadian government (table 4.8), most strikingly in communications and information technology, but also in the areas of energy, finance, transportation, and government. Due in part to physical geography, a varied climate, and extensive integration with the United States, Canada joins the United States in being one of the most space-dependent nations on the planet.

In recent years, Canadian national security policy in general, and more specifically, its emergency preparedness policy have increasingly stressed the importance of critical infrastructure (CI) protection. Canada's 2004 *National Security Policy* (NSP) lists critical infrastructure vulnerability as one of the most important current threats to Canadian security. This growing concern led to the release of a follow-up government position paper on the subject of CI in 2004. As the document notes, "Canada defines its national critical infrastructure (NCI) as those 'physical and information technology facilities, networks, services, and assets which, if disrupted or destroyed, would have a serious impact on the health, safety, security, or economic well-being of Canadians or the effective functioning of governments in Canada' " (Privy Council Office 2004, 5). Space assets clearly fit this description, especially on the economic front. However, they currently are not officially recognized as CI, partially because Canada possesses so few of its own. Canada's lack of ownership, however, does not cancel out their criticality. Arguably, it increases Canada's vulnerability to possible space-generated economic disruption.

Early efforts to identify CI have been directed towards energy infrastructure and cyber security. In the United States, military and non-military space assets have been clearly identified as CI in policy. The inclusion of non-military assets is partly due to the growing reliance of the American military on commercial space services. The importance of space assets to national economic well-being is also well recognized in the United States' policy, and this is arguably no less the case for Canada.

In the event of a complete loss of space-based services, six economic sectors (Agriculture; Mining and Oil/Gas Extraction; Transportation and Warehousing; Information and Cultural Industries; Finance and Insurance, and Public Administration), which together account for C\$258 billion of activity, would be seriously impacted. At just a 5 per cent productivity loss in these sectors, the impact would be C\$13 billion. However, the impact would not end there. It would reverberate across the entire economy. In GDP terms, a complete loss of space-based services – weather, navigation information, timing synchronization, and communications – would cost the Canadian economy tens of billions of dollars in lost productivity. Arguably, it would also cost the world in excess of C\$150 billion and a decade to replace the systems (based on an estimated satellite replacement cost of C\$250M). It would potentially make the 1997 Red River flood or the 1998 ice storm appear as minor national inconveniences in economic terms. The effects would be felt across the entire country and around the world.

The United States' investment in space and the investment of some 200 other nations, organizations, and agencies exist for good reason: the ability of space applications to collect, create, and disseminate valuable, rare, and difficult to replicate information. Three particular service areas illustrate the deep impact that space assets provide to the larger economic picture at the national and global levels.

Table 4.8
Canadian GDP Space Reliance, by Economic Sector
 C\$Millions
 (Statistics Canada, 2006)

2004 GDP	Space Applications Used	Space Reliance
Agriculture, Forestry, Fishing and Hunting		
\$24,050	Weather services, GPS (positioning) and growing remote sensing services (e.g., precision agriculture)	High
Mining and Oil and Gas Extraction		
\$14,318	Remote sensing, GPS (positioning), Communications	High
Utilities		
\$27,530	Weather info, Communications	Low
Construction		
\$63,661	GPS (positioning)	Medium
Manufacturing		
\$185,124	Communications	Negligible
Wholesale Trade		
\$68,670	Communications	Low
Retail Trade		
\$63,146		Negligible
Transportation and Warehousing		
\$52,054	Weather info, GPS (positioning), Communications	High
Information and Cultural Industries		
\$44,553	Communications	High
Finance and Insurance		
\$64,227	GPS (timing), Communications	High
Real Estate Rental and Leasing		
\$140,126	GPS, Remote sensing	Low
Corporate Finance, Insurance and Real Estate		
\$212,757	GPS, Remote sensing	Low
Professional, Scientific and Technical Services		
\$46,158		Negligible
Admin Support, and Waste Management Service		
\$23,898		Negligible
Education Services		
\$47,016	Weather, Remote and science data, GPS	Low
Health Care and Social Assistance		
\$61,511		Negligible
Arts, Entertainment and Recreation		
\$9,881	Weather services, GPS (positioning)	Negligible
Accommodation and Food Services		
\$23,130		Negligible
Other Services Except Public Administration		
\$26,003		Negligible
Public Administration		
\$58,913	Weather and remote data, Communications, GPS	High

Earth observation and remote sensing date back to the earliest days of space flight. Space advocates argued for the use of space systems to monitor the world's weather. Prior to 1960, weather predictions were obtained through an extensive terrestrial system of weather stations and observers, with tracking and forecasting attempted by collating a host of dispersed, soda-straw-type observations. With the advent of space-based sensing, understanding weather patterns was greatly simplified, and forecasts became immensely more accurate. Viewing space-based weather imagery has become so routine on the morning or evening news program that the source of the images has been forgotten and undervalued. Yet weather monitoring and forecasting is perhaps today's most critical space-based service. Its loss would be extremely costly, particularly for a nation like Canada. Today, high ground observation is not only used for weather prediction, but for a growing host of other purposes (table 4.9).

Table 4.9 Remote Sensing Applications		
Civil and Scientific Purposes	Military and Security Purposes	Commercial Purposes
Weather forecasting Environmental monitoring Ice monitoring Crop damage assessment Forest fire monitoring Scientific observation Natural resource management Disaster monitoring Search and rescue Cartography and earth imaging	Intelligence collection Terrestrial surveillance Marine surveillance Arms control verification Peacekeeping support Homeland security Border monitoring	Geological prospecting Real estate transactions Insurance claim evidence Education and entertainment

On the heels of providing revolutionary weather coverage, space-based systems also began providing long-haul remote and mobile communications. Today, satellite communications is the most successful commercial space activity, and a broad spectrum of civil and military users depend on them. Satellite communications are integrated into the global communications network, providing a range of vital services to lesser and greater degrees (table 4.10). They have been fully integrated into the Canadian lifestyle, principally the Canadian economy and security. Outside of the United States, Canada has the largest space transponder use per capita of any country in the world. With over 25 million North American subscribers, satellite television dishes are readily observable in all the nation's communities, as are the daily news broadcasts remotely generated from around the world via satellite. The North American market accounts for 45 per cent of the global commercial communications revenue, and North America promises to consume more satellite services with the coming prominence of high definition television, broadband internet, and satellite radio (ISBC 2005).

Robust alternative terrestrial communication exists in and between urban centres. However, satellite communication plays a critical role in the national communications architecture because of its broadcast and remote mobile advantages. That potential was clearly recognized by Canada in the early days of space. Today, Canadians call upon satellite communications on a daily basis.

It is also a standard medium for the world's Fortune 500 firms to connect their global facilities, to broadcast in-house news and training programs, and to move financial and credit card transactions. Over the last five years, Canadian satellite communications revenues from systems manufacturing and service provision have almost doubled, growing from C\$0.9 to C\$1.8 billion (CSA 2005). The loss of space-based communications would be immediately evident to Canadians as they would no longer be able to find their favourite television show, use the automated banking machines, or board a flight without being seriously delayed at the airport.

Table 4.10
Satellite Communications Applications

Civil and Scientific Purposes	Military and Security Purposes	Commercial Purposes
Mobile communications Remote communications Tele-medicine Tele-education Emergency and disaster response	Strategic command and control Secure communications Integrated defence systems Emergency/backup networks Battlefield connectivity Tactical data-link Tactical video	TV and HDTV signal distribution Direct-to-home broadcast Private data networks IP/Internet access Rural telephony Broadband internet Satellite radio Mobile services Paging services Digital film distribution Asset/fleet tracking

Also affecting these aforementioned communication services would be the absence of GPS, the global positioning and timing system that is changing the nature of global movement, the synchronization of disperse systems, and geospatial surveying and mapping. The global positioning system has now become a ubiquitous and critical asset (table 4.11), with a new system, the European Galileo project, under development and the Russian Glonass system being re-constituted. From its initial military applications, global positioning satellite signals have been integrated into dozens of sectors including aircraft, marine, automobile, and cellular telephony. For example, the Canadian fishing fleet's use of GPS for navigation has increased its productivity and reduced fuel costs, for example, by enabling vessels to return to specific fishing spots on the seas.

The GPS not only provides accurate positioning, but also acceleration and timing information. It now provides time synchronization for stock exchanges and banking transactions worldwide, while simultaneously providing navigation services for ships, trains, and aircraft alike. Private consumers purchased over two million GPS sets in 2004 alone. When one accounts for the value of GPS electronics and for products containing GPS chipsets, today's market worth of more than C\$5 billion could triple by the middle of the next decade (ISBC 2005).

The world is rapidly adopting space-based navigation services and forsaking past systems for the growing precision and the global/mobile nature of GPS. A reduction or denial of GPS services would present huge problems today. In ten to fifteen years, when old systems have been fully

phased out and current and new uses are further developed and entrenched, their loss will have far more dramatic consequences.

Table 4.11 Satellite Navigation and Timing Applications		
Civil and Scientific Purposes	Military and Security Purposes	Commercial Purposes
Land/marine navigation Air traffic control People and animal tracking Surveying and mapping Timing and synchronization	Land/marine navigation Air traffic control Targeting Weapons delivery Command and control Tracking Timing and synchronization	Automotive navigation Systems Automotive safety network Robotics and machinery control Recreation Vehicle and freight tracking

Space-based services have become critical to Canada's well-being, and this requirement will only increase in the future. These services, as discussed in chapter 3, are also vulnerable to disruption as more nations acquire the technology to threaten space-based assets and the information they provide. In the face of this growing criticality and vulnerability, nations like Canada have to become more concerned about space development and security and be prepared to respond to the loss of space services, in whole or in part. Not only is space home to three critical information systems for an advanced economy, but space investment is vital to a nation's overall scientific, technological, and economic growth.

Conclusion and Recommendations

Global space activity tied to the ongoing maintenance and growth of some 700 active satellites is worth in excess of C\$110 billion annually. The United States enjoys unquestionable dominance. However, Russia, Japan, and Europe (led by France) also enjoy comprehensive programs and independent space access. The populations of China and India are rapidly building equivalent capabilities, and the prominence of the role satellite systems play in their daily lives is growing at a similar rate. Outside these dominant players, Israel also enjoys independent space access, while upwards of two dozen other nations invest more than C\$10 million in space programs annually.

Space operations, overwhelmingly driven by the leading space nations, are comprised of three arenas of activity: civil, military, and commercial. Reflective of America's overall presence, the United States leads investment in all three. Civil and military space operations have risen significantly in the last few years, and predictions are that this trend will continue. Outside of NASA, with its strong exploration mandate, civil space agencies are increasingly directing their efforts towards more terrestrially focused space applications and services. For the time being, military space, while remaining problematic for many nations, is also primarily driven by these terrestrially focused applications. Commercial activity has rebounded after the past five difficult years, with the future looking much more promising, particularly for direct-to-home satellite radio and broadband services and further GPS usage, as well as expanding PPP opportunities with government.

While space use is often overlooked, it is ultimately dependent upon the world's space manufacturing industries and on the space education and corporate services that support them.

While commercial space activity is important, space development and manufacturing remains highly dependent on government investment and contracts. It is also highly protected and subsidized by the world's first-order, space-faring nations. It has suffered from soft downstream demand over the last five years, but it will ultimately see an upturn in demand as space operations steadily increase and new technologies generate new opportunities.

While Canada's dependency on space-based services is steadily growing, it has limited control or influence over the provision of those services, and it relies heavily on the services, and often the goodwill, of others. Furthermore, in the face of this highly competitive and protected international space manufacturing market, Canada has distanced itself from space development over the years. As a result, Canada's space industry today is largely skewed towards end-user needs and sub-system technologies. It is an export-focused industry, arguably enjoying stronger international loyalties than domestic. Moreover, through the CSA and in the absence of DND, Canada has progressively allotted scarce resources to space science and exploration.

Canada's vulnerability to a disruption or denial of space access is increasing, and if such an event occurs, its ability to respond independently is minimal. It has little capacity to reconstitute lost services quickly without assistance from its friends and allies. In such a situation, Canada's needs, to the extent that they diverge from the needs of others, will be of secondary importance, or worse. Moreover, Canada has a sovereignty issue as a function of its high dependence on foreign-provided services. Canada also appears largely unprepared for future commercial opportunities in space, which may affect Canada's economic competitiveness and thus the well-being of its citizens. **Space services have a particularly deep impact on the world's most advanced economies. This impact will only increase in the years ahead, as will Canada's dependency and its vulnerability.**

Recommendations include:

- **Space systems be recognized as critical infrastructure in Canadian security policy and contingency planning;**
- **Canada's space services and manufacturing industry be strengthened and rebalanced through selecting "developed and built in Canada" solutions wherever possible, and/or through the strategic use of domestic and international public-to-public and public-to-private partnerships; and**
- **National space policy seek balance and synergy across national military, civil, and commercial interests and activities, and it should mandate, fund, and enforce the long-term, progressive growth of national space competencies.**

CHAPTER 5

CANADA, NATIONAL SECURITY AND SPACE MANAGEMENT

Introduction

One of the primary responsibilities of national government is to provide for the safety and well-being of its citizens. This responsibility, according to classical democratic social contract theory, stems from citizens giving up certain aspects of their freedom in exchange for the security provided by the state. Naturally, governments have other major responsibilities that cannot and should not be ignored. Nonetheless, these other responsibilities logically follow after the provision of security. This is the rationale behind the ideal that the populace's national security is the government's priority.

The problem governments have, however, is defining a national security threat or concern that requires some form of response, either alone or in conjunction with others. There is no clear operational definition that can be easily applied. Traditionally, such threats have been seen in terms of other states, and more recently, non-state actors (terrorists) and internal actors who possess the means and/or intent to use force to strike at the territorial, institutional, and socio-political values of a state. The traditional government response has been primarily to invest resources in military and/or police forces to manage the threat of violence and create a sense or feeling of security for the nation and its citizens. Governments also seek support or assistance from other states for security purposes.

Naturally, disagreement generally exists over the nature and extent of any external or internal threat and the preferred means to manage it. Moreover, the very process of threat definition and identification is inherently subjective and wrought with political implications. There are significant costs associated with attributing national security to any issue by a government. It creates demands for a government response that can exacerbate feelings of insecurity. It may mean taking actions that undermine other national values, such as the loss of certain legal freedoms, as has occurred with anti-terrorist legislation after 9/11. It also usually requires a reallocation of national resources which undermines other priorities and creates winners and losers inside and outside of government.

For these reasons and in the absence of clear evidence and public pressure to act, governments are reluctant to treat many issues in national security terms. This is evident in the instance of space. Space is not on the national political agenda in any meaningful sense. The government has not truly looked at space in a systematic manner since the 1967 *Chapman Report*, notwithstanding attention paid to space with the establishment of the CSA in 1989 and attempts within CSA to move space forward.

There is also little evidence that Parliament sees space as a significant national security question. Even in a recent Senate report, *The Government's No. 1 Job: Securing the Military Options it Needs to Protect Canadians* (2006), space was not treated in a systematic national security sense, but rather in a piecemeal manner related to weaponization (reverse course), exploiting Radarsat better, and a generic reference to the Joint Space Project with the United States. This approach was also reflected in the unsystematic way space was considered in the 2005 *International Policy and Defence Policy Statements*; a reference to non-weaponization in the former and to surveillance from space in the latter (Govt. of Canada 2005; DND 2005).

Moreover, it is evident in the way space is structured within Canada. There is no overall management/administrative structure within the Government of Canada capable of moving space on to the national security agenda and developing a national policy and investment strategy. Instead, the Interdepartmental Committee on Space, which apparently has declined in influence and importance over time, reflects the interests of the individual departments rather than providing a truly integrated, national perspective.

Space has a very minor profile within the department assigned the national security file: Public Safety and Emergency Preparedness Canada (PSEPC). In DND, space is seen almost exclusively in project terms within the Joint Capabilities Production section reporting to the Chief of Force Development, rather than an independent strategic security issue for the defence of Canada. In Foreign Affairs, which has been active for decades in promoting space security by pushing for an international agreement on non-weaponization, space security has had a relatively low profile. It is largely located within a much larger section devoted to arms control and disarmament.

As the primary agent for space, the CSA is located within Industry Canada, and its mandate is largely commercial and scientific. Despite its best efforts to provide national leadership on space, it remains dependent on gaining the support, not only of Industry Canada, but also of other departments in the battle for profile and resources. **At the end of the day, none of the departments with functional interests in space services are overly willing to sacrifice traditional departmental interests and preferences that may result from defining space in national security and interest terms.**

The “bottom line,” so to speak, is that the growing emergence of space as an independent strategic domain and of space services as vital to a modern, information-based economy and society requires a national management structure that gives space an independent voice and profile, per se. It must begin with a systematic, independent, national study that not only examines space in national security terms, but also looks at alternative national structures that will ensure that space receives the attention and resources essential for the future.

Space Management and the Government of Canada

Escaping from the past, or transformation and change, is always difficult for large, functionally defined organizations. Adapting to change is one of the most difficult, yet significant, tasks confronting organizations over time. This is especially true in the case of space, as it does not fit neatly into any of the existing functional definitions of federal departments. Many departments, for example, Environment Canada, Transport, and Indian and Northern Affairs, are all users of space in varying degrees, but have no functional responsibility for it. Even CSA is trapped in some ways as a dependent of Industry Canada.

Successful bureaucratic change requires leadership (Rosen 1994). Unfortunately, the Government of Canada is not well placed to provide it. It is trapped by the immediacy of democratic politics. However, overcoming the treatment of space as a relatively marginal interest in Canada is the job of the whole of government, because none of its parts are either capable or willing to tackle the requirement for a fundamental, strategic re-think of space.

Moreover, with space out of sight and out of mind, nothing on the surface appears to threaten the status quo and thus push any of the actors to advocate for such a re-think. Limited niche investment, public/private partnership, international co-operation, and non-weaponization, all principles established during the Cold War and all now being the dominant space thrusts, appear to be sufficient. Beneath the surface, reliance and dependence upon the United States is also viewed as unproblematic.

Yet all of these assumptions are problematic, not least of all because Canada's engagement in space has declined, and there are growing security concerns. Both need to be addressed, and this requires a central advocate and voice. As the central coordinating agency for Canada in space, the CSA is, or should be, Canada's primary advocate for space. Yet unlike PSEPC, CSA is not an independent agency with a direct voice in cabinet and government. Instead, it must compete with other interests for ministerial attention and support, especially within Industry Canada. At one level, the relationship may be simply understood by the state of relations between the President of CSA and the Minister of Industry, the specific interests of the minister, other competing voices within the department itself, and the government agenda.

The first two will tend to produce inconsistency over time. As ministers change (as do presidents), so too will the nature and level of support. This works against long-term planning. Space, especially in the national security agenda, demands long-term, consistent attention and commitment. Other competing voices, even with the CSA obtaining its own separate budget line, are likely to see space in zero-sum terms relative to existing programs and budgets. From a relatively fixed fiscal pie, any additional money given to space is likely to be seen as a loss to other programs. The long-term demands and returns of space are likely to lose out to the immediate demands of other industrial and technological programs. These, in turn, are likely to have more resonance with governments driven to sacrifice the future for the present by the nature of democratic politics.

In addition to the constraints of Industry Canada, space advocacy is also affected by the nature of relations with other departments and with the inter-departmental governing process. The former is most evident in the evolution of the CSA's relationship with DND which should, arguably, be its closest ally. As discussed below, the distance between them can be attributed to two factors; organizational images and organizational commitment. Devoted to the peaceful exploitation of space and populated by scientists and engineers, the image of DND as an organization of armed force and war is clearly at cross-purposes with peaceful use and development; a variant of the psychological non-weaponization barrier.

Organizational images and commitments also filter through the Inter-departmental Committee on Space. Such a committee makes natural sense when many departments across government are users of space. Moreover, any attempt to develop a true national policy and strategy (as distinct from a CSA or DND departmental one) will require an inter-departmental process and buy-in, notwithstanding the Cabinet or the Prime Minister's Office dictating such a policy/strategy.

However, being a user does not establish a necessary interest in space itself. Like DND, other government departments may see space as useful as long as it doesn't require any significant diversion of resources away from their traditional preferences. Thus, the inter-departmental process is just as likely to work as a means to block space initiatives or re-confirm the status quo as it is to support such initiatives. This is particularly true when the primary advocate, CSA, doesn't even have a truly independent voice. In the end, departments are willing to exploit the capability, but they do not see space as an independent operational environment or domain because their organizational images prevent it. Such images also make departments unwilling to pay for space.

In the end, space is buried within the governmental process itself, its access to cabinet constrained, and its message diluted. **Unless the process is re-structured to give space an independent voice in, and access to, cabinet (perhaps borrowing from the model used in India of a separate Ministry of Space), then as it currently exists, the only hope lies with Cabinet and the Prime Minister.** However, with space far removed from the existing political agenda (and a potential minefield relative to other interests and non-weaponization), it is also highly unlikely that the senior decision-makers will act. The knowledge is simply absent, as the expertise and advocates for change are largely buried within the governmental process and the various departments.

Space Management and Public Safety and Emergency Planning Canada

Like the whole of government and other departments, space is at best on the margins of PSEPC's national security mandate. For now, there is no clear operational threat to the nation that would move it beyond the margins, notwithstanding the longstanding threat of ballistic missiles carrying nuclear or other types of warheads transiting through space. Instead, the threats that do exist are from the possibility of debris falling upon Canada from Russian polar orbit rocket launches (and perhaps launches from the proposed private launch facility in Cape Breton in future), a de-orbiting satellite or space debris that doesn't burn up upon entry (as in the case of

the de-orbiting of Cosmos 945 in 1978 that spread radioactive material across the Canadian north), or an asteroid that would put into motion emergency responses, and thus the coordinating function of PSEPC. All of these are monitored through a variety of means, including access to data from the United States' SSN and NORAD.

Beyond this function, there is nothing within its mandate primarily devoted to terrorism and pandemics that would logically place space onto its agenda for the time being. Terrorists are not likely to be able to access missiles, rockets, or satellites to strike at targets in Canada or North America, although they might be able to disrupt signals electronically.

With regard to the Critical Infrastructure (CI) side of PSEPC's mandate, formal responsibility for CI is assigned to the relevant line or functional department. Space in this regard is Industry Canada and its subordinate unit, the CSA's, responsibility. Public Safety and Emergency Planning Canada in these cases only plays a coordinating and facilitating function. Only in the case of the government category within the CI list is PSEPC responsible. Here, space is not considered CI, notwithstanding its possible consideration in their forthcoming new strategy document as a function of the significance of space services to the government.

Whether space should become its own category in CI is an important question. Notwithstanding the relative and variable criticality of space to the other CI categories (Energy and Utilities, Communications and Information Technology, Finance, Health Care, Food, Water, Transportation, Safety, and Manufacturing), most space services critical to the nation are either commercial or foreign. With the exception of defining Canadian ground station or end-user capabilities in CI terms, Canada has to rely on others to protect the CI of space.

In these circumstances, the essential role of PSEPC is to be aware and sensitive to the critical role of space in the existing sectors. This should include an assessment of which services are truly critical and difficult to replace with alternative terrestrial ones. This should also entail developing contingency plans in the event that space services are lost, whether accidentally or intentionally. This includes the identification of the possible requirements and the availability of satellites to reconstitute the service quickly. In many cases, Canada can rely upon other states and/or commercial ventures to respond quickly. However, there may be some circumstances where Canadian national requirements dictate a national reconstitution capability rather than reliance upon others.

In order to accomplish this task, which may include a national reconstitution capability for communications, disaster management, and sovereignty surveillance, PSEPC should create an analytical section devoted to space as a critical infrastructure. From such a basis (and reflective of its coordinating function), it should also take the lead in establishing an interdepartmental working group on space security with the participation of the three other main organizations concerned with space security issues: Department of National Defence, Foreign Affairs, and the CSA. These steps will become more significant as dependence on space services continues to grow, and as Canada becomes somewhat more of an active player in space, especially if a national radar satellite surveillance constellation planned by CSA and DND goes forward. As direct threats to assets on orbit and to Canada from assets on orbit grow in the future, this function will also need to expand into its broader, national security mandate.

Space Management and National Defence

The Department of National Defence and the Canadian Forces have been the primary agents of national security in Canada, partially because most threats have been seen in military terms and located overseas. From the late 1960s until the late 1980s, DND ostensibly withdrew from space with the passing of the mandate on space to the civil side of government. Its involvement was largely limited to research and development, of which the current microsatellite surveillance of

space is the most recent example (Defence Research and Development Canada 2006, 35). Otherwise, access to space related information was overwhelmingly derived from the United States through NORAD.

The Department of National Defence and the CF began to pay more attention to military space owing to a number of factors: the role of space assets in the Gulf War; the politics surrounding the creation of CSA; and the 1985 parliamentary report recommendation that a military space program should be established (Godefroy 2006). In 1991, the Space Development Working Group was established under the Deputy Chief of the Defence Staff (DCDS), followed by the creation of the Directorate of Space Development, also under the DCDS. In 1992, the first formal *Defence Space Policy* was issued. It was updated in 1998.

As noted in chapter 3, the 1998 *Space Policy* clearly defines space in security terms and touches upon the key points, issues, and capabilities relevant to space and national security. However, the policy does little to treat space as a separate or distinct security environment. Rather, it reflects the tendency to view space in end user terms. Furthermore, investments to acquire the capabilities advocated by the policy have been delayed, especially if one considers the Joint Space Project (JSP) with the United States.

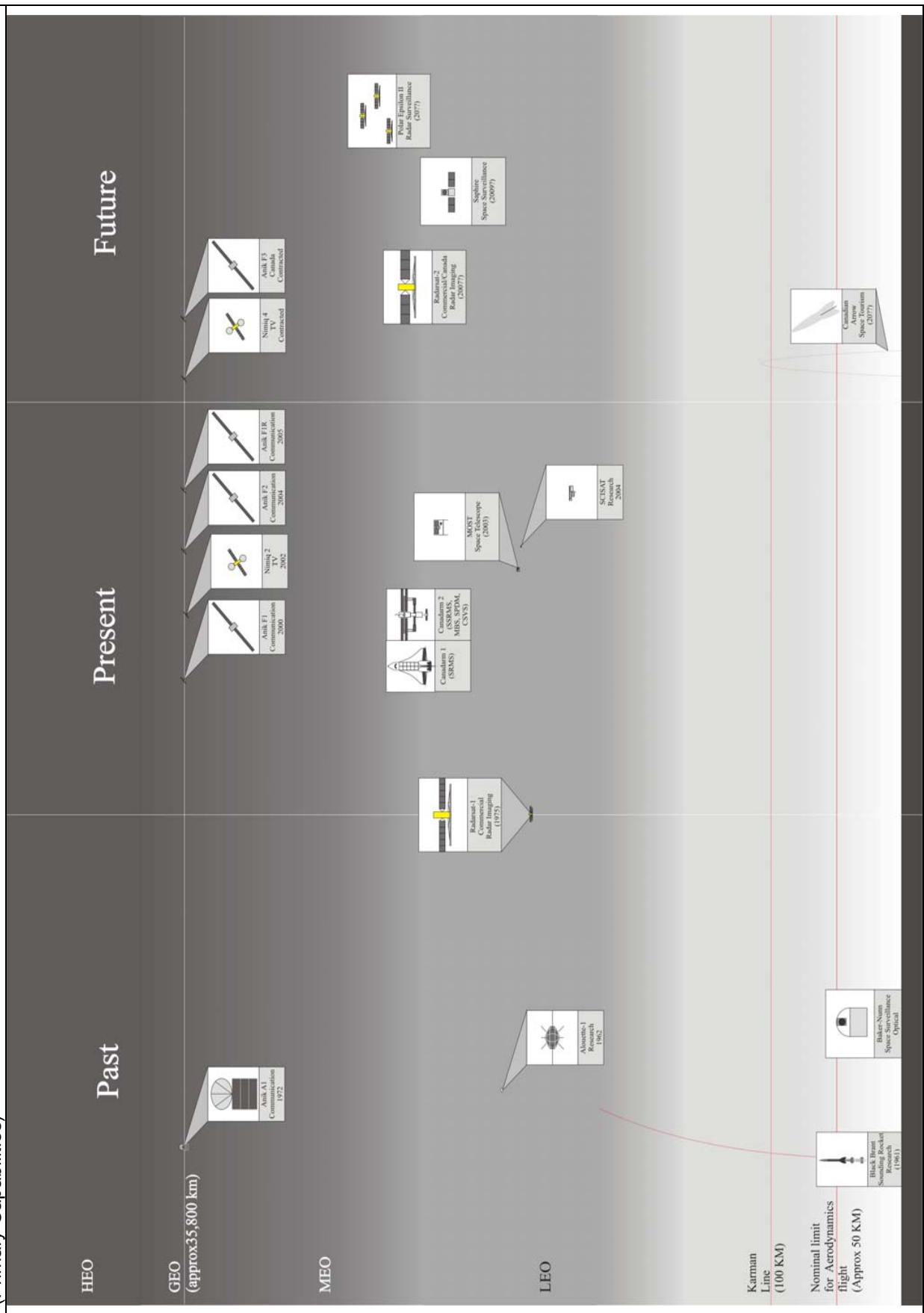
Reflecting end-user thinking within the Department, space as a security issue is not reflected in the recent *Defence Policy Statement* (DND 2005). It warrants only two references, and one is a relatively vague commitment to “pursue the use of satellites to support domestic and international operations” (DND 2005, 14). This, in turn, was then formalized last June by identifying Radarsat I (and in the future, Radarsat II) imagery for national sovereignty and security functions (Polar Epsilon I). However, this occurred many years after the initial capability was deployed and its replacement developed.

As an end-user requirement, space services are naturally seen in a supportive role for traditional land, sea, and air requirements. This role is reflected in its position within the DND structural hierarchy, especially following the re-structuring that took place following the development of the *Defence Policy Statement* in 2005 and the establishment of Canada Command, Canada Expeditionary Forces Command, Canada Special Forces Command, and Canada Operational Support Command. With the elimination of the DCDS, responsibility for space was assigned to the new Chief of Force Development, and it was downgraded from a directorate to a section within the new Joint Production Capabilities Directorate. In so doing, space has remained within a capabilities-project envelope. More importantly, its status declined as it was moved one step further away from direct access to senior decision-makers.

Other parts of DND are also engaged in space defence and security issues. Analysts within the Assistant Deputy Minister for Policy (ADM-POL) and the Vice Chief of the Defence Staff (VCDS), the strategic planner for the CF, continuously monitor international and strategic space issues. However, there is no dedicated directorate or section within either the civil or military side of DND devoted to military security space. With only five space projects of note, and only one of them, Sapphire, entailing a dedicated national defence satellite, an integrated, high level directorate that includes strategic planning, policy development, and project management might be seen as unnecessary (fig. 5.1). This assessment is logical when space is still largely viewed in end-user services terms and when reliance upon the United States and the perceived high costs of space relative to other service capability requirements stemming from the impact of budgetary constraints and existing operational demands are both considered.

However, none of these perceptions or longstanding beliefs about military and national security space are likely to be effectively challenged within DND and the CF in the absence of a high level, integrated voice at the status of director-general able to advocate for space's inclusion on the defence and security agenda. As space services and space itself continue to increase in importance, the danger that DND and the CF will act on the basis of out- dated beliefs grows. At best, Canada is likely to lag behind other states in responding to the new strategic world of space.

Figure 5.1
Canada in Space
(Primary Capabilities)



An alternative to an integrated, high level directorate is to vest space with the Canadian air force and the Chief of the Air Staff. Historically, space has generally been an air force responsibility. In the case of Canada, the Canadian air force through NORAD has generally been the primary actor for space. However, even within the air force, and arguably the position of Deputy Commander of NORAD as the major space advocate, space has been somewhat marginal. It must compete with traditional organizational images surrounding air power and air capabilities (planes). Thus, vesting the Air Force and the Chief of the Air Staff as the primary advocate for defence and security space may be insufficient to meet emerging challenges and ensure an independent, integrated voice.

The importance of re-structuring and establishing an integrated, single, high level group staffed at the general officer level also stems from the primary defence and security function of the department. As DND and the CF are tasked with the defence and security of Canada's air and maritime approaches, so it should also be tasked with space approaches. In the maritime context, DND does not operate alone, but takes a lead role in conjunction with other government departments (OGDs), as evident in the case of maritime security and the recently established Maritime Security Operations Centres. Whereas the Canadian Navy leads in this context, there is no central, dedicated, high level organizational point within DND for coordinating space security with OGDs, and there is no Space Security Operations Centre, notwithstanding the CSA space flight centre in St. Hubert, Quebec, and the manner in which the analytical imagery centres of Polar Epsilon I evolve.

Reflecting the whole of government question, the structural management of space security issues and space in general between DND and OGDs has more of an ad hoc, rather than formal, character. There are formal arrangements, particularly between DND and CSA, based upon a memorandum of understanding (MOU). This includes a Management Board, co-chaired by the President of CSA and formerly the DCDS, a Standing Co-operation Committee, Joint Working Groups, an Advisory Committee on research and development, and an exchange of liaison officers. Yet as discussed below, the actual relationship has been somewhat problematic, in part because space does not have an independent high level position within Defence. Like CSA's relationship within Industry Canada and with OGDs, space is only one of many considerations for DND. It is not a relative priority as it is for the CSA.

The structural or organizational issue also affects relations with allies. This is of particular concern relative to the vital bilateral relationship with the United States as a key part of DND's longstanding space strategy. Currently, the relationship embodied in NORAD, the Joint Space Project, and the bilateral Space Co-operation Working Group remains largely project and end-user focused. While DND does engage the high level National Security Space organization within the Pentagon, it does so from a relatively low priority position instead of one of organizational equality. Whereas senior officials within National Security Space are dedicated to this one issue, Canadian senior officials, if engaged, do not come from a dedicated position, per se. Engagement and influence beyond end-user, project focused discussions as a means to advance Canada's national security space interests requires organizational equality.

Similarly, Canada's engagement with other allies in space will be affected by the relative status accorded to space within the organization. Australia, for example, faces similar national policy and organizational issues regarding space. Nonetheless, Australia appears to be moving forward, having established a Defence Space Engagement Directorate within the Strategy Executive and a Defence Space Coordination Office under the Chief of the Air Force (Sach 2003). In order to ensure effective engagement, it is essential that DND's treatment of space within the organization reflect its position as a priority relative to other allies like Australia. Otherwise, Canada is likely to become more marginal as it lags behind organizationally while others move forward.

Space Management and Foreign Affairs

For Foreign Affairs, space has always been about security, and space security has been nearly exclusively seen as arms control and disarmament. Certainly, the department played the lead role

in drafting national legislation on remote sensing, which is not arms control. It has also developed a space security index project that surveys expert attitudes on a broad range of space security questions (Lawson 2004). It has also shifted its space security strategy somewhat away from the earlier concentration on creating an international treaty prohibiting the weaponization of space. In so doing, it has begun to concentrate on promoting multi-lateral measures to manage a range of pressing space security questions, such as launch notification, debris mitigation, and orbital slots.

However, this shift into space regulatory issues, not dissimilar to the process leading to an international regulatory regime to manage air traffic (the International Civil Aviation Organization located in Montreal) does not mask the continuing dominance of an arms control perspective on space security. This is not to suggest that arms control should be rejected in favour of an alternative broader regulatory approach to space security. Small regulatory steps serve not only to promote international co-operation and common interests in ensuring the safe use of space, but they also serve significant arms control and confidence building goals promoting transparency. Nonetheless, regulatory measures are more than just arms control. Such a concentration can skew or de-value other national interests with regard to space security, notwithstanding the tension such a concentration has on relations with the United States regarding space security, as the United States sees space more in regulatory terms.

Indicative of this concentration organizationally is the dominance of the Non-Proliferation, Arms Control, and Disarmament Division beneath the Director-General, International Security Bureau within Foreign Affairs. **Like DND, there is no devoted, integrated, high level directorate or division for space that would span the full range of national security and international space issues.** Even within the division, space is only one of several sub-groups, and the relevant director is tasked with other non-proliferation, arms control, and disarmament issues. In fact, the actual number of personnel devoted to space security is much less than it is within DND. Senior officials like the Director-General, when engaged, are not dedicated to space security. Instead, it is only one of many files they are responsible for.

Not only should Foreign Affairs devote more resources to space issues and expand from a relatively narrow, arms-control focus to a more integrated, multi-dimensional approach, it should elevate space in a manner as is suggested here for DND. In the broader context, Foreign Affairs, while engaged in the larger inter-departmental process, should push for a much more formal, national approach to space. Specifically, its arrangements with DND are too ad hoc, reflecting the overall approach to space in Canada. Most of Canada's space activities are international in nature, bringing Foreign Affairs into the equation. As such, it is essential that formal, high level coordination become one of the foundations of a national security approach to space.

Finally, the organizational elevation of space in Foreign Affairs and the integration of the different dimensions of space security (including arms control, regulatory, and economic perspectives) are important for Canada on the world stage. Canadian influence, notwithstanding the problem related to Canada's relatively small presence in space, will depend in many ways on international perceptions of the significance of space in Canada. These perceptions will be affected by the manner in which Foreign Affairs organizationally approaches space. A low level organizational approach to space, alongside a one-dimensional concentration, will affect Canada's ability to influence space.

Space Management and the Canadian Space Agency

The CSA, established by an act of Parliament in 1989, is Canada's only dedicated agency, and by extension, its only advocate for space. Its mandate is "to promote the peaceful use and development of space..." (CSA 2003, 3). Housed within Industry Canada and reporting to its minister, the CSA's natural focus is, or should be, economic development and the employment of space for economic value. In security terms, this translates into the well-being of Canadians, evident in the references to security made in its recent strategy document (2003).

The economic/commercial dimension has been one focus of Canada in space. Two of its strategic pillars are telecommunications and earth observation (or remote sensing). Telecommunication was Canada's original focus in space, and the CSA's roots go back to the Defence Research Telecommunications Establishment. The creation of the CSA was driven by the need to provide better coordination for Canada's space effort with, and in support of, industry. It was made possible, however, by the Mulroney decision to participate in President Reagan's ISS initiative.

Certainly, public investment has been crucial to the development of a space industry. The initial high costs of entry, first in telecommunications and subsequently in earth observation, combined with a largely non-existent commercial market, demanded a public lead. In this regard, space was, and still remains in some ways, a classic sunrise industry. Today, the telecommunications market, led by Telesat Canada, is well developed on the private side. In terms of the future economic well-being of Canadians, it will likely remain in the hands of a mature, commercial marketplace with a range of new services including satellite radio and direct digital television broadcast. The same cannot today be said for earth observation. Not only is the private marketplace still in a sunrise state, but government remains the largest user of remote sensing information.

The use of space for economic value (terrestrial purposes), however, has always competed with the exploratory (space science) side of the CSA equation. Populated by space scientists and engineers, exploration arguably has been of greater internal interest than economic exploitation. Indeed, for a great many years, CSA exploration spending has exceeded economic-related spending.

Of course, the two are not necessarily at odds with one another. Its space robotics investments, the Space Shuttle and ISS Canadarms, certainly have industrial significance. As new technologies make access and exploitation more affordable, past and future efforts might bring even greater economic payoffs, prepare Canadian industry to be at the forefront of these developments, and translate into the enhanced well-being of Canadians. For example, one of the growing security-related problems in space is debris; garbage on-orbit threatens operating satellites, and garbage de-orbiting threatens Canada directly. Space robotics will be a vital technology for the first generation of space garbage collectors.

Organizationally, there are several issues confronting CSA relative to security when it is defined as well-being. These partially reflect the functional division of labour within government in which the first part of security – safety – generally falls within the mandate of traditional security departments like DND. As such, neither organization can take the lead with respect to national security space without the other. In other words, **CSA and DND need to coordinate national security space to ensure a holistic national security approach as the leading national organizations.** While the current MOU represents a starting point, deepening the relationship is a priority. Both parties need to overcome their organizational biases; the CSA to overcome the psychological barrier of its “peaceful use and development of space” mandate, and DND to commit resources to joint policy and project development. Both should also remove suspicions that the other is only seeking resources to advance their organizational interests.

Indications of movement in this direction are evident, especially with a planned, coordinated approach to a future Radarsat constellation for both national surveillance and sovereignty (national security) purposes. In this regard, coordination is essential to deal with different technology requirements related to their different mandates. Military requirements or specifications are generally much greater than commercial or civil. For example, there was little need from a commercial perspective to develop and deploy ground moving target indicators (GMTI) on Radarsat II, but the potential military value is immense for both national and international operations. As such, the experimental GMTI was funded by DND. This model, wherein DND funds militarily-specific technology or militarily driven, technological upgrades, should continue.

Given the budgetary constraints that both CSA and DND confront, coordination and non-duplication of effort should also extend into project definition and development. Unless there is a dramatic increase in government investment, every CSA project should be developed in co-

operation with DND. For instance, growing threats to satellites on orbit require direct consideration in every future project of passive defensive measures such as hardening. Such measures are a national security add-on, and thus arguably a responsibility of DND. Similarly, CSA and DND need to work together to establish a single Space Security Operations Centre manned by personnel from both.

As noted above, the CSA leadership side of the equation is also hampered by its location within Industry Canada. With largely indirect access to Cabinet, the CSA's space advocacy must compete with other and more established industrial priorities within the department. A promising first step to overcome this competition has been made with the establishment of its own budgetary line, notwithstanding the need to expand its budget. The next step should be to establish its own formal direct link with Cabinet through a junior minister solely responsible for the CSA and space. This minister should also become a member of the National Security and Foreign Affairs Cabinet Committee.

It is too early to move directly to the Ministry of Space model used in India, even though the growing significance of space and space services will likely effectively require such a move in the future. The defence and military side of space is excluded in that case (not unlike the situation in Canada), but at a higher bureaucratic level. However, the costs of the duplication of effort from separate military and commercial/civil efforts are prohibitive for Canada, notwithstanding the political case for separation. An integrated ministry approach needs to be examined following an overall restructuring of space within and amongst the relevant departments and as part of a systematic national examination of Canadian space policy and interests.

The case for granting CSA greater independence from Industry Canada also stems from the treatment of space in combination with the air industry under the rubric of aerospace. As discussed in chapter 4, there is an organic link between air and space on the industrial side. However, there are also significant differences, including the comparative economic dominance and maturity of air and the significant environmental differences of the two domains. There is also a relatively small but dedicated space industrial and technology sector. **As such, independence with industrial responsibility for space in conjunction with a more integrated governmental approach is likely to be valuable for developing the space sector, and through it, enhancing the well-being of Canadians as the future unfolds.** For industry, it will potentially provide a valuable single point of contact, thereby enhancing Canadian space competitiveness in a sector which remains significantly dependent upon government engagement.

There are numerous other issues confronting CSA from an organizational perspective. With the recent establishment of a policy arm, a step forward to enhancing space advocacy within government has been taken. However, CSA continues to be dominated by science and engineering perspectives. Independence within a re-structured whole of government approach will necessitate other perspectives, including devoted policy ones. In so doing, the CSA will also have to step out of its current organizational predilections to meet the challenges of the future.

The CSA also needs to look closely at its approach to education as a means to raise the profile of space on the public agenda. Notwithstanding the importance of space science and engineering recruitment through education, there is a much larger requirement to inform the public about space and space services, both services currently available and those likely to be developed in future. In one sense, raising the profile has been a rationale for the astronaut program. Whether the investment in this program which has seen seven Canadians go to space on twelve shuttle missions, has been functionally valuable should be closely examined. Regardless, as an educational strategy to ignite public awareness and passion, it does not appear to have had much success.

Finally, like DND and DEA, the elevation of CSA within the governmental structure and process will be important for Canada internationally. In this regard, a national examination of space and CSA itself should look closely at the steps taken by similar nations. In addition, there is a pressing need

to look at the nature and value of CSA's relations with other nations, including the United States (NASA) and Europe (ESA), relative to Canadian interests and national security requirements.

Elevating space to meet existing and future opportunities and challenges from a national security perspective requires the CSA, as well as OGDS and the whole of government, to undertake a broad re-examination of current strategy, policy, and practices. Today, the CSA, reflective of the overall condition of space in Canada, arguably remains trapped in the past. Space and space services have evolved significantly since the early 1990s, and will continue to do so. CSA independence will be of little value unless it is accompanied by a close, critical examination of past beliefs in light of the ongoing changes in the nature and significance of space and space services to the nation.

Conclusion and Recommendations

Arguably, no one at the decision-making level sees space and space services in its entirety. The functional division of labour within government ensures that space is viewed as specific, functional parts. In defence parlance, it is a capability or a location for a platform (satellite). It does not have the status of an environment, like land, sea, and air. Yet we are witnessing the birth of an environment with its own economic dynamic and security requirements.

Unless the whole of government responds and the departments re-structure, one can expect little, if any, change. The actors will refer to Canada's limited existing effort, the highlights of the past, and of course, the unforeseen nature of the future. They may refer to the over-selling of space in the late 1990s, and suggest it would be premature for Canada to gamble and speculate on the future. But space has changed, while Canadian policy has remained static. Unless the government undertakes the strategic development of an updated national space policy entailing a harmonized policy approach to space, Canada will be caught unprepared in the future and will remain dependent on the good will of others, especially the United States.

No one would suggest that Canada has the capability and will to become a truly independent, first-order, space-faring power, but neither should we accept even more Canadian dependency when it comes to space.

Recommendations include:

- **Canada's space advocacy be elevated and strengthened;**
- **The Canadian Space Agency be given independent representation in Cabinet and in relevant Cabinet Committees, including Foreign Affairs and National Security;**
- **PSEPC take the lead in establishing an inter-departmental working group on space security;**
- **Department of National Defence and Foreign Affairs establish dedicated Director-General space organizations;**
- **CSA and Department of National Defence jointly coordinate national space investments, ensuring the optimization and synergistic employment of Canadian civil and military space resources.**

APPENDIX A: GLOSSARY OF SPACE TERMS

Advanced Extremely High Frequency (AEHF)/ MILSTAR III	USA military communication satellite program to provide increased bandwidth, more security, and survivability for forces. Canada has invested approximately C\$470M to acquire secure access for its own operations and to enhance interoperability. Expected to be operational in 2010.
Aerodynamic Flight	Flight through lift generated by movement of an airfoil (wing or lifting body). Movement of a lifting generating shape causes air across one side to speed up verses that on the other, generating lower pressure on that side of the airfoil and consequently lift.
Anti-Ballistic Missile (ABM) Treaty	1972 treaty as amended by 1974 protocol limiting the Soviet Union and the USA to a single, 100 interceptor, ground-based missile defence around either the national capital or an ICBM field. The Soviet Galosh system around Moscow remains operational. The American Safeguard system around the Grand Forks ICBM field was shut down in 1975. The treaty ended with the United States' notification of withdrawal in December 2001.
Air Launched Miniature Homing Vehicle (ALMHV)	American ASAT program from the 1970s through to the 1980s. A small, kinetic energy interceptor (the Miniature Homing Vehicle, or MHV) and its multi-stage, sub-orbital launch vehicle launched by an F-15 into the path of an orbiting target where the MHV would find and lock onto its target via infrared optical sensors and conduct terminal manoeuvres to ensure the MHV collided with its target.
Alouette	Canadian series of research satellites, the first of which was launched in 1962. The successful launch of Alouette 1 (by a USA launch vehicle) made Canada the third nation to have a satellite in orbit, after the Soviet Union and the USA.
Anik	Name for a series of GEO communication satellites operated by Telesat Canada from 1972 to the present. The first of these satellites, Anik A1, was the world's first commercial, domestic, GEO communication satellite.
Anik E1 and E2 Failures (1994)	Both E series Anik satellites suffered damage to their flight control (orientation) caused by solar activity. Eventually both were brought back under control.
Ansari X-Prize	Private competition to encourage the development of space technology by the private sector (prize rules forbid government sponsorship). Formerly X-Prize (1996–2004), renamed "Ansari X-Prize" after significant donations by members of the Ansari family. Prize was won by Scaled Composites' <i>Tier One Project (Space Ship One)</i> on 29 September 2004 after completing two flights within: time (two weeks), reusability (except for propellant, 90%), and payload (three adults) criteria; to space (defined by the Karman line, 100 km. above sea level).
ASAT	Anti-satellite weapon.
Baker-Nunn Camera	A type of large telescope and camera system. Canada deployed a camera at Cold Lake, Alberta (1961–81) and at St. Margaret's Bay, New Brunswick (1976–92) as its contribution to the USA's Space Surveillance Network. Sapphire, discussed below, is slated to be the Canadian replacement.

Bent Pipe	A term used in telecommunications to refer to how two ground stations without line-of-sight to each other use a satellite (typical GEO communication satellite) to cover long distances. A signal is transmitted from one ground station to the satellite, which re-transmits the signal to the receiving ground station without further processing.
Black Brant	Sounding rocket (sub-orbital) manufactured by the Canadian company, Bristol Aerospace. It has been employed in a variety of missions, including as a target for missile defence tests.
<i>Bogotá Declaration</i> (1976)	The formal claims of several equatorial states (Ecuador, Colombia, Brazil, Congo, Zaire, Uganda, Kenya, and Indonesia) to sovereignty over the geostationary orbit slot directly above their airspace. Their intention is not to eliminate satellites located at these points, but simply to charge rent.
Boost Phase Intercept	The ideal missile defence intercept which targets a missile during its initial launch phase when it is most vulnerable (a single large, slow target that is easily detectable by its heat signature) as it rises from the ground prior to exiting the atmosphere and detaching from its boosters.
Brilliant Eyes / SBIRS- Low/Space Tracking and Surveillance System (STSS)	American early warning and missile tracking satellite constellation program, meant to support ballistic missile defence, originally identified during the SDI years. Space-based infra-red satellite network (SBIRS) in low earth orbit is designed to provide cold temperature tracking and target discrimination of warheads during their mid-course phase for the cueing of intercepts. It will be a constellation of around two dozen satellites. It has been plagued by a variety of development problems and cost overruns.
Budget, Delta-V (velocity)	The expected amount of manoeuvring or Delta-V (change in velocity) capacity a satellite expends in its lifetime. Often a limiting factor in a satellite's "lifespan."
Canadarm	Nickname for the Canadian-built Remote Manipulator System (RMS) which comprises a major Canadian contribution to recent USA space activities. The Canadarm 1 is the first generation system used with the United States space shuttle fleet. The Canadarm 2 is an advanced, second generation system mounted to a moving platform on the International Space Station.
Canadian Arrow	Space tourism concept being developed by a Canadian company, Planet Space. It is predicated on what is now public domain A-4/V-2 technology captured from Second World War Germany.
Canadian Space Agency (CSA)	Federal agency established in 1989 and responsible for Canada's space program. Enabling legislation is the Canadian Space Agency Act.
<i>Chapman Report</i> (1967)	Privy Council (of Canada) Science Secretariat report concerning Canada and space. Titled formally as: <i>Upper Atmosphere and Space Programs in Canada</i> . It is the only major study of space commissioned by the government.
Comdev	Canadian engineering company specializing in space hardware subsystems.

Committee on the Peaceful Use of Outer Space (COPUOS)	United Nations committee formally established in 1959. UN Resolution 1472 is an international forum on the use of space. It presently has two standing subcommittees: Scientific and Technical Subcommittee, and Legal.
Constellation	The use of multiple satellites to provide continuous coverage. As one satellite moves out of the line of sight, another takes its place. For some applications, such as GPSs, it is necessary to have line of sight with multiple satellites, resulting in large constellations often distributed among multiple orbital planes.
Co-orbital ASAT	Soviet Union ASAT program that involved the orbit and rapid rendezvous (under one orbit in later tests) of an interceptor satellite with its target. On rendezvous with the target, a conventional explosive would throw "hot metal" at the target satellite. This program ran from the mid 1960s to at least the late 1980s, reportedly including twenty or so orbital test intercepts, the majority of which were deemed successful. The present status of the ASAT program is unclear, as is whether the system was actively deployed during the last years of the Cold War.
Cosmos 954	A nuclear powered Soviet satellite that was not boosted to its disposal orbit and instead re-entered the atmosphere. Debris from 954, including nuclear material, affected most of Northern Canada.
Coverage	In the context of this discussion, the area on the earth's surface that may be "serviced" by a satellite at a given moment. See also: Footprint.
Defense Intelligence Agency (DIA)	USA intelligence organization under the Department of Defense which provides intelligence resources to all branches of the military.
Defense Support Program (DSP)	A small constellation of infra-red early warning satellites maintained in GEO for the purpose of missile early warning. The satellites feed into the Missile Correlation Center, NORAD. Primarily designed for long range, ballistic missile threats, it proved successful in detecting the launch of SCUD missiles by the Hussein regime during the 1991 Gulf War.
Defensive (Body Guard, Sentinel) Satellite	A satellite meant to protect another satellite from attack by potential ASAT weaponry. The distinction between defensive and offensive is controversial because the satellite is also able to apply coercive force against a target.
Delta-Velocity (Delta-V)	A change in velocity. In the context of spaceflight, intentional Delta-V is produced by propulsion, either by rocket-type engines or through an exotic and largely untried system such as an electrodynamic tether that uses electro-magnetic principles to obtain thrust.
Directed Energy Weapon	A means of attack where destructive energy is not transmitted to a target by physical means (ramming, fragmentation, or concussion). Generally refers to laser, radio frequency, particle beam, and electro-magnetic, pulse-based weapons.
Directorate of Space Development (DSPACED)	Former directorate within Canada's DND responsible for space reporting to the Deputy Chief of the Defence Staff. Replaced by a section within the Directorate of Joint Capabilities Planning reporting to the Chief of Force Development.

Earth Imaging (Earth Observation or Remote Sensing)	Using satellites to provide pictures of the earth's surface. This initially referred to reconnaissance missions, but now includes all manner of civilian and commercial applications including mapping, forestry/agricultural surveys, environmental monitoring, and the sheer novelty of seeing one's house from orbit. Recently, there is a growing trend to use commercially obtained earth imaging data for military purposes, including the use of commercial satellites to provide maps of theatres of war in both Afghanistan and Iraq, as well as Canadian plans to use commercial imagery (Radarsat) for polar and maritime sovereignty surveillance.
European Space Agency (ESA)	Inter-governmental agency coordinating the majority of space efforts among member nations and their space agencies. Canada has observer, or partner, status.
Footprint	The area on the earth's surface that may be "serviced" by a satellite at a given moment. See also: Coverage.
Fractional Orbital Bombardment (FOB)	Soviet-era strategic strike system, envisioned to bypass the United States' early warning radars directed northward by using an orbital trajectory (with an apogee well below that of the average ICBM) from a southern trajectory to approach the United States after almost completing a full orbit, and present a shorter period of visibility to any horizon-limited sensors facing such an attack. FOB's orbit and de-orbit characteristics give it ideal first-strike or surprise attack capabilities. The status of such systems under the OST's ban on orbiting nuclear weapons remains a matter of academic debate to this day. Later arms reduction treaties prohibited systems operating under the FOB concept.
Galaxy 4	On 19 May 1998, the Galaxy 4 Satellite in GEO suffered a catastrophic failure in its altitude control system and backups, resulting in disruption of service to thousands of pagers, televisions, and gas station payment systems that suddenly lost their connection through space.
Galileo (GPS)	Originally a French military-security initiative and now a project of the ESA, with China's participation, to compete with the American GPS system. The constellation will consist of 30 satellites in 3 orbital planes. A first test satellite was launched in 2005, with operational status projected for 2010. Canada, after initial consultation, declined to participate.
Glonass (GPS)	Soviet, now Russian, equivalent to the American Navstar GPS constellation.
Ground Station	Includes both ground control facilities and recipients of a satellite's services. In the case of GPS for example, USA satellite control facilities, handheld receivers, and receivers built into moving equipment (ships to guided munitions) would be counted as ground stations.
Ground Target Moving Indicator (GTMI)	Concept to use space-based radar to provide detection of moving targets on the ground. DND funded experimental capability on Radarsat II.
Group of Eight (G8)	Informal grouping of eight of the world's leading industrialized nations which meet at an annual summit, originally to discuss economic matters. In addition to Canada, the Group of Eight includes France, Germany, Italy, Japan, Russia, the UK, and the USA.

Hardening	Shielding and other measures to protect a satellite. Every satellite is shielded in some manner against the space environment, particularly natural radiation sources such as cosmic rays and the Van Allen Belts (for satellites that spend time in that region). Basic shielding is generally insufficient to defend against the radiation effects of a nuclear detonation in space.
High Ground, Ultimate	In military (army) terms, the high ground bestows numerous advantages. It signifies the strategic importance of space. Many space power advocates refer to space as the “ultimate high ground,” often with the suggestion that the control of space (earth orbital space) will lead to dominance in all other environments of human conflict.
Hybrid Launch Vehicle	A multi-stage, partially reusable launch vehicle where the initial stage is reusable and later stages are expendable. The first stage does not reach orbital velocities and therefore has greatly reduced costs (both financial and technical) associated with recovery. The term is also used to describe a launch vehicle that uses hybrid rocket propulsion.
Hybrid Rocket	A rocket engine where one of the propellants is solid and the other either a gas or a liquid. Typically, it is the fuel which is a solid with a liquid or gas oxidizer. These types of rockets presently offer a trade-off in performance in favour of low cost and safety.
International Space Station	The USA-led space station project for a range of space science purposes, whose member nations include Canada. Announced by President Reagan in the 1984 <i>State of the Union Address</i> for completion within a decade, the first module was launched in 1998, and the station is not yet completed. It is currently more than ten years behind schedule and double the original cost estimates of US\$50B.
Interoperability	The ability of national forces to work or fight together. In the Canadian context, it refers to the Canadian Forces fitting in seamlessly with United States Forces. It requires not just hardware but also compatibility in force structures, doctrine, and training, among other factors.
International Policy Statement (IPS)	Integrated Canadian policy from April 2005 entitled <i>International Policy Statement: A Role of Pride and Influence in the World</i> . Four additional component documents are Diplomacy, Defence, Development, and Commerce.
International Telecommunications Union	A UN agency tasked with co-ordination of radio frequencies and the allocation of GEO orbital slots.
International Traffic in Arms Regulations ITAR	United States regulations controlling the import and export of defence and security sensitive technologies.
Japan Aerospace Exploration Agency (JAXA)	The relatively new Japanese space agency formed in 2003 from three previously separate entities.
Joint Direct Attack Munitions (JDAMS)	A type of American, precision-guided munition using a combination of GPS and inertial navigation to achieve low-cost, all-weather, day/night, precision strikes.

Joint Space Project (JSP)	Bilateral program between Canada and the USA. For Canada, it was a means of improving access to space-based information systems, such as communications and intelligence gathering.
Joint Tactical Air-to-Ground Station (JTACS)	AMERICAN system for direct, in-theatre warning of a ballistic missile attack, used to cue theatre and tactical missile and air defence batteries such as the United States Patriot SAM/ABM batteries.
Kick Motor/Engine/Stage	A rocket engine that, on firing, is meant to change the shape of a spacecraft's orbit, either from an initial parking orbit to a transfer orbit, or to change a transfer orbit into the final mission orbit.
Kinetic Energy Weapon	A weapon that employs the energy of an object in motion through collision to destroy another object. In space, the high speed (plus Mach 25, for example) of an object (satellite or warhead transiting through space) is struck by another object (non-explosive warhead) travelling at similar speeds, such that the combined force of the collision is sufficient to destroy the target. This is the preferred intercept method of the range of American missile defence systems, all but the airborne laser.
Launch Vehicle	A vehicle (rocket, missile) designed to move a payload into or through space. With respect to orbital space launch, it must be able to overcome gravity and accelerate a payload from what is typically a standstill to an initial orbital velocity needed for stable orbit.
Launch Vehicle, Expendable	A launch vehicle which is used once with no effort made to recover it for further use.
Launch Vehicle, Reusable	A launch vehicle which is recovered for reuse. Scaled composites are fully reusable. Space Ship One/Tier One is a suborbital vehicle only. The American Space Shuttle, Soviet Buran/Energia system, and SpaceX's Falcon 1 are the only partially reusable orbital launchers to have attempted spaceflight. There are currently no examples of fully reusable, orbital launch vehicles.
<i>Liability Convention</i> (1972)	Formally titled the <i>Convention on International Liability for Damage Caused by Space Objects</i> , it elaborates upon Article VII of the OST which establishes responsibility for an object to the launching state that is liable for damage caused by space objects (satellites) on earth, land, sea, or in space. It also establishes procedures for settling compensation claims.
<i>Limited Test Ban Treaty</i> (1963)	Bilateral USA-Soviet Union treaty prohibiting all nuclear tests above ground, including in space and on the sea bed.
MacDonald, Dettwiler & Associates, Ltd.	Canadian company involved in information systems, including those for military and space applications (including space hardware). Prime contractor for Radarsat II and Sapphire.
Mach Number	Ratio between the speed of an object and sound under the particular environmental conditions present for the object. Space does not present an adequate medium for sound transmission, hence there cannot be a speed of sound in space. Spacecraft velocities are often made in comparison to terrestrial Mach numbers (1225 km./hour at sea level). Mach 25 is the speed needed to reach a minimum orbit.

Maritime Economic Zone	Offshore territory claimed by a nation for economic use. Canada claims an economic exclusion zone extending 200 nautical miles.
Mid Course Intercept	Interception of a ballistic missile after its engines have finished firing, and the missile payload (warhead) is coasting though to its apogee and onward to the re-entry or terminal phase of ballistic missile flight.
Mid-Infrared Advanced Chemical Laser (MIRACL)	American experimental laser facility located at the White Sands Missile Range, New Mexico. This is a megawatt class chemical laser, which in the course of its use in experiments, has demonstrated latent ASAT capabilities. In 1997, with much controversy over its weaponization potential, MIRACL was used to test the vulnerability of United States satellites to laser attack by briefly illuminating a soon to be out of service USAF satellite.
MILSTAR	United States military communication satellite program. The AEHF (Milstar 3) program is the third generation of satellite to carry the Milstar name.
Mission Payload	Equipment devoted to its mission that is carried by a satellite.
<i>Moon Treaty</i> (1979)	Formally, the <i>Agreement Governing the Activities of States on the Moon or Other Celestial Bodies</i> , it was meant to clarify a range of issues not fully dealt with in the 1967 <i>Outer Space Treaty</i> . It was never ratified and is not in effect.
National Aeronautics and Space Administration (NASA)	American space agency responsible for civilian space exploration, among other missions or purposes.
National Missile Defense	Clinton-era United States anti-ballistic or ballistic missile defence program involving the use of ground-based, mid-course interceptors. Its direct successor is the American ground-based, mid-course phase system operational as of 2006 at Fort Greely, Alaska and Vandenberg Air Force Base, California.
National Oceanic and Atmospheric Administration (NOAA)	Part of the USA Department of Commerce and focused upon weather science and weather prediction, operating numerous satellites.
National Reconnaissance Office	United States agency that builds and operates reconnaissance satellites.
Navstar GPS	United States global positioning system. Navstar GPS provides not only free, accurate positional data, but also an accurate timing signal on which most electronic financial transactions are synchronized. Gathers accurate location and accurate timing data, also implies accurate motion data for moving objects equipped to receive GPS, allowing for its use in PGMs. It emits two signals; the less accurate public c/a code for general use and the encrypted p code for military use.
North American Aerospace Defence Command (NORAD)	Bi-national partnership between Canada and the United States that has guarded North American airspace against intrusion since 1958. The agreement was renewed indefinitely in 2006.
North Atlantic Treaty Organization (NATO)	Based upon the <i>Treaty of Washington</i> (1949), it is the Western collective defence organization originally designed to deter and defend Europe during the Cold War. Canada is a founding member of this organization.

Office of Critical Infrastructure Planning and Emergency Preparedness	Former Canadian organization under the DND concerned with critical infrastructure and emergency response planning. It is now part of the new Department of Public Safety and Emergency Preparedness that was established after 9/11.
Open Skies	Confidence building measure for treaty verification purposes allowing for over flight of national territory by a state that is party to the treaty. Originally proposed by President Eisenhower in 1955, a formal treaty was negotiated between NATO and the then <i>Warsaw Pact</i> in 1992, and came into formal effect in 2002.
Orbit	To completely circle a body. The un-powered or free-flight state where, barring other forces, a spacecraft will circle the earth indefinitely due to a combination of gravity and the momentum imparted earlier by propulsion from a launch.
Orbital Inclination	The angle between the orbital plane and the equator. A geostationary orbit by definition must have an orbital inclination of 0 degrees.
Orbital Period	The amount of time it takes for a satellite to complete one orbit.
Orbital Plane	An orbit can generally be described on a flat plane which bisects the earth.
Orbit, Geostationary or GeoEarth (GEO)	A circular orbit at about 35,800 km. above the earth's equator giving a satellite an orbital period of one day, resulting in the satellite "hovering" above a point on the equator. Also called the "Clarke" orbit after author Arthur C. Clarke, who popularized the concept.
Orbit, Geosynchronous (GEO)	Similar to geostationary, it has a circular, low inclination orbit. In many circumstances, it is used synonymously with geostationary or as a generic type that includes geostationary.
Orbit, High Earth (HEO)	Any orbit beyond the nominal 35,800 km., geostationary orbital altitude.
Orbit, Intermediate or Medium Earth	An earth orbit with an altitude between that of the upper limit of LEO (2,000 km.) and below that needed for GEO orbit (approximately 35,800 km.).
Orbit, Low Earth (LEO)	An earth orbit found between the altitudes of 150 km. and 2,000 km. above the earth's surface.
Orbit, Molniya	Highly elliptical orbits (perigee ~200 km., apogee ~40,000 km.) with an inclination of 63.4 degrees or 116.6 degrees, and an orbital period of about 12 hours, which gives the satellite extended coverage (on the order of 8 hours) over high latitudes.
Orbit Perturbations	Factors which cause an orbiting body not to follow the calculated orbit. It is a function of drag from the fringes of the earth's atmosphere at LEO altitudes, differences in gravity from the fact the earth is not the perfect sphere (used in calculations), 3 rd party gravitational influences, and collisions.
Orbit, Polar	An orbit with an inclination of 90 degrees or so.
Orbit, Transfer	An elliptical orbit that intercepts both the original and the "destination" orbit. See also: Kick Motor/Engine/Stage.

Orbit's Apogee	The highest, or furthest from earth, point in an orbit.
Orbit's Perigee	The lowest point in an orbit, or the nearest point to earth.
<i>Outer Space Treaty</i> (OST) (1967)	Formally the <i>Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies</i> , it is the foundation of the international legal regime governing space. It establishes outer space, the Moon, and other celestial bodies as international in character and for the use of all mankind. Specifically, space is treated the same as international waters, open to freedom of passage. It only prohibits the deployment of weapons of mass destruction (primarily nuclear weapons) in space, implicitly defined as an object completing a single orbit, and testing weapons, conducting manoeuvres, or establishing military bases on the Moon or on other celestial bodies.
Palapa B1	Indonesian owned Palapa B1 in 1996 directly jammed APSTAR-1A, a satellite owned by a Hong Kong-based company, during a dispute over use of an orbital slot. This (in)famous incident is widely cited as an early example of open conflict (attack) in space. Of particular note is that no major space powers were directly involved. Palapa B1 was American built and launched, and APSTAR-1A was American built and Chinese launched when Hong Kong was still British territory. Earlier in 1992, Palapa B1 challenged a satellite owned by Rimsat, an American company, for use of that very same GEO slot.
Parasite Spacecraft ("Space Mine")	A satellite sent to orbit in formation with an opposing powers' satellite, ready to conduct some action on command. Often in the context of ASAT spacecraft, but can also be used for less active surveillance.
Polar Epsilon I	Canadian program to use commercial earth imaging data for surveillance of Canada's Arctic and maritime territories.
Polar Epsilon II	Canadian program to use space-born radars for 24/7 surveillance. Canadian plans to use multiple space-born radars date to 1985. It has an as yet unfunded budget of C\$47M.
Precision Guided Munitions (PGMs)	Munitions with onboard terminal guidance capable of hitting exceedingly close to the target. Also referred to as "Smart" or "Brilliant" weapons.
Prevent an Arms Race in Outer Space (PAROS) Committee	Ad hoc UN Conference on Disarmament Committee, its mandate is regularly proposed, then effectively blocked by the United States for more than the past ten years.
Prompt Global Strike	The future capability to strike any point on earth with non-nuclear weapons measured in hours and minutes. Candidate technologies include hypersonic trans-atmospheric vehicles and manoeuvring PGMs delivered by sub-orbital re-entry vehicles.
Public Safety and Emergency Preparedness Canada (PSEPC)	As of 2003, Canadian department responsible for, "developing and implementing federal policies for emergency management." As part of its responsibilities, it has taken over the role of OCPEP.

Radarsat	Canadian radar imaging satellite program. Thus far in the series, <i>Radarsat 1</i> has been in orbit since 1995. The next satellite, <i>Radarsat 2</i> , is scheduled for a 2007 launch.
<i>Registration Convention</i> (1976)	Formally, the <i>Convention on Registration of Objects Launched into Space</i> , it requests that states maintain a national registry on objects launched into space and forward the registry to the UN.
<i>Rescue Agreement</i> (1968)	Formally, the <i>Agreement on the Rescue of Astronauts, the Return of Astronauts, and the Return of Objects Launched into Outer Space</i> , it requires state parties to facilitate the rescue and return of astronauts and objects.
Revolution in Military Affairs	Often used to describe paradigm shifts in military power, whether brought on by operational or technological changes. In the present context, it refers to the information age doctrines and hardware which, it is argued, has brought about a “new” way to fight wars.
Rocket	A self contained propulsion system that works by expelling propellant in a direction opposite to the direction of flight. At its most basic, a rocket is an implementation of Newton’s Third Law of Motion: for every action, there is an equal and opposite reaction. A rocket ejects via some kind of energy source, a “reaction mass,” in one direction, resulting in thrust in the opposite direction. In a chemical rocket, the propellants (oxidizer and fuel) both generate the energy and provide the reaction material. Thermal rockets have an external heat source (nuclear, solar, beamed energy, etc.) that provides energy to expel “reaction mass.” Electric rockets use electrical and/or magnetic principles to accelerate “reaction mass,” often in the form of charged particles.
Rocket Science	Phrase used to describe something as being exceedingly technical and difficult. Also used as a part of a derogatory statement in that the task being referred to <i>is</i> exceedingly simple and therefore is <i>not</i> rocket science.
Sapphire Project	Canada’s only dedicated defence satellite program consisting of a single optical satellite in LOE to conduct surveillance of the outer orbits. When launched in 2008, it will represent Canada’s only contribution to the United States Space Surveillance Network.
Satellite Bus	Conception in satellite design, the “chassis,” or platform, onto which mission equipment is mounted.
Satellite Telephony, Rise and Fall in 1990s	In the mid–1990s, there was great interest in establishing large constellations of low orbiting communication satellites to service relatively small, handheld portable phones. Competing technologies, such as fibre optics and cellular phone networks, proved more cost effective, leaving parts of the satellite communication industry in serious trouble, including Iridium.
Scramjet	Supersonic combustion ramjet.
Shenzhou	Chinese manned spacecraft, similar to Soviet/Russian Soyuz but larger and with an orbital module capable of independent, unmanned on-orbit manoeuvre/ mission once the re-entry capsule has separated for the return to earth.

Shuttle Control	In the context of this discussion, regulatory and legal means imposed on companies offering remote imaging services to control the flow of such data to potential hostile powers.
Small Satellites	<p>As computers become increasingly more powerful and smaller, more capability can be fitted into smaller payloads. One result has been the development of smaller satellites, sometimes classified further as:</p> <ul style="list-style-type: none"> • Mini-satellite, 500 – 100 kg. • Micro-satellite, 100 – 10 kg. • Nano-satellite, less than 10 kg. • Pico-satellite, less than 1 kg. <p>There is no official or standardized terminology for classifying satellites by size.</p>
Space-Based Space Surveillance (SBSS)	Proposed United States constellation of satellites for the purpose of monitoring objects in earth orbit. This program has reportedly had its schedule moved forward with the scheduled launch of the <i>Pathfinder</i> satellite moved up to 2008.
Space Command, United States (USSPACECOM)	From 1985 until 2002, when it was incorporated into United States Strategic Command, United States Space Command was the unified (joint) command over American military space operations.
Space-faring, first and second order	Space analogy with maritime's "seafaring" to describe a nation which has a certain competence in the various areas of space power. In this context, a first-order nation possesses the full range of space capabilities, whereas a second-order nation lacks an independent launch capability. As such, Canada is a second-order, space-faring nation.
Space Force Application	Generally, the application of coercive (military) force in space against orbiting targets, and from orbit against terrestrial targets. By some definitions, mid-course missile defence systems also qualify, as interception of an ICBM would occur in space. There are some schools of thought that also include weapons passing through space between terrestrial launch and target points (i.e., long range ballistic missiles).
Space Force Enhancement	The use of space-based assets to greatly enhance terrestrial warfighting abilities in comparison to an "un-enhanced" force. The use of space assets is said to have a "force multiplication" effect, allowing a comparatively small force to perform tasks that previously required larger investments.
Space Force vs. Air and Space or Aerospace Force	With the growing importance of space, there are suggestions that an independent space force or service be established. The United States Air Force debate over a space force has led to the idea of it being a space and air force, or an aerospace force. Compounding the issue are parallels between space and naval warfare in which science fiction writers envision a space fleet and a space navy.
Space Lines of Information (SLOI)	Space analogy with the maritime concept of sea lines of communication. Whereas communications at sea refer to maritime commerce and transport of military force, the space medium provides a medium for primarily one important good and service; the acquisition and movement of information, hence its usage in SLOI.

Space Militarization	The use of space assets for military purposes. These range from Cold War era, strategic surveillance, to present day force enhancement, and in the future, force application. It is currently distinguished from the weaponization of space, which by legal default, consists of deploying a conventional weapon in orbit.
Space Sanctuary	Strategy where space is kept “weapons-free” (ASAT-free) through norms and agreements, so as to allow its use for strategic surveillance, early warning (in the context of nuclear war), and lately, space force enhancement. Policy statements notwithstanding, due to limitations on technology, this is the de facto situation at present.
Space Shuttle	Used to conceptually describe various real and proposed spacecraft using wing born flight, usually for recovery. It generally refers to the United States Space Transportation System, which is a partially reusable, crewed launch vehicle.
Space Surveillance	In the context of this discussion, knowing what is in orbit that may present a hazard (i.e., “space junk”) or a threat (i.e., satellite doing the bidding of a hostile force).
Space Weaponization	A rather contentious term, it generally refers to a situation where space force application is widely practiced by one or more nations. At present, due to “latent” space weapons capabilities found in nuclear armed missiles (fused to go off at high altitude), space weapons experiments (such as the MIRACL laser facility at White Sands, New Mexico), and the fact that ballistic missiles do transit through space, the distinction between today’s state of space militarization and weaponization can be described as “fuzzy.”
Spar Aerospace	Canadian company responsible for the original Canadarm. It is now part of MDA.
Staging, Multi	To improve the payload and structure vs. fuel mass ratio. Staging is used to shed dead weight (by dropping spent stages) as a launch vehicle ascends. Tsiolkovski’s Rocket Equation provides the mathematical rational for multistage rockets.
Staging, Single	While staging offers relaxed mass fractions for payload, it is operationally expensive due to the complexity of having essentially multiple vehicles which must all operate correctly. For a rocket powered, single stage to orbit vehicle, it is not uncommon for the propellant to make up between 80–90 + % of the total launch mass. Air breathing propulsion allows for lower propellant requirements as the oxidizer is largely supplied by the environment.
Starfish Prime	The American test in 1962 of a 1.4 megaton warhead at an altitude of 248 miles over the Pacific Ocean. It caused a blackout of communications over the area and permanently damaged three satellites on-orbit. In 1963, such tests were prohibited with the <i>Limited Test Ban Treaty</i> .
Strategic Air Command (SAC)	United States Air Force Command which operated ICBM and bomber forces during the Cold War. It is now part of United States Strategic Command.

Strategic Command (USSTRATCOM)	Current United States unified command which, among other missions, is responsible for United States military space operations and United States nuclear deterrent forces (ICBM, bombers, and Submarine Launched Ballistic Missiles). Just recently, two subordinate commands for each mission were established – Space and Global Strike.
Strategic Defense Initiative (SDI) or Star Wars	Ambitious American ballistic missile defence research and development program which included substantial space elements, including orbiting weapons. Proposed in 1983 by Ronald Reagan and scaled back considerably by his successors, SDI led to many research programs which have a direct bearing on today's debate on limited missile defence and space weapons. In 1985, the Canadian government under Brian Mulroney declined the invitation to participate, but did allow Canadian companies the right to join in.
Strategy 2020, Canada	June 1999 Chief of Defence Staff policy statement concerning modernization of the Canadian Forces. It particularly emphasized the vital importance of interoperability with allies (read the United States).
Sub-Orbital	A spacecraft that has at least achieved the nominal definition of space (the Karman Line at 100 km. altitude) but does not have the momentum needed to complete one orbit and is pulled back down by gravity.
Sub-Orbital Space (sometimes referred to as "Near-Space")	Region between the limits of aerodynamic flight (approximately 50 km. altitude) and the minimum altitude where an un-powered orbit will not rapidly decay (approximately 150 km.). This region is often referred to as a "no-man's land" between aeronautics and spaceflight, as it very difficult to do more than simply traverse this area on rocket thrust. Very-high-altitude ballooning (in the lower parts of this region) and some trans-atmospheric vehicle technology (for the higher end) may allow exploitation of this domain.
Teal Ruby	American research program into satellite-based, infrared sensors used to detect aircraft from space. Canada and Australia participated in the project.
Telesat Canada	Canadian telecommunications company which owns and operates the Anik GEO communication satellites and the Nimiq direct broadcast satellites.
United States Army 1997 Winter War Game	In the United States Army's 1997 Winter War Game Army After Next, the BLUE Team, an RMA force of 2020, was brought to the negotiating table by near-peer RED Team after detonating several nuclear weapons in space, crippling BLUE Team's ability to fight. The findings also estimated that the attack plunged the world economy into global depression for over a decade.
Unmanned Aerial Vehicle (UAV)	In contemporary terms, this refers to semi-autonomous aircraft. For beyond line-of-sight operations from ground controllers, UAVs depend on satellite communications to relay back data and to receive commands. GPS navigation is also important for UAV operations.
Unmanned Combat Aerial Vehicle (UCAV)	Armed UAV aircraft. While ad hoc, anti-armour armed Predator UAVs may be considered UCAVs, this term is generally used to describe a dedicated autonomous warplane able to reach and engage targets with little supervision.
Vision for Space Exploration (VSE)	2004 United States policy that includes completion of the ISS, retirement of the Space Shuttle, shuttle replacement (spacecraft recently named Orion), return of crewed expeditions to the Moon, and eventual crewed exploration of Mars.

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