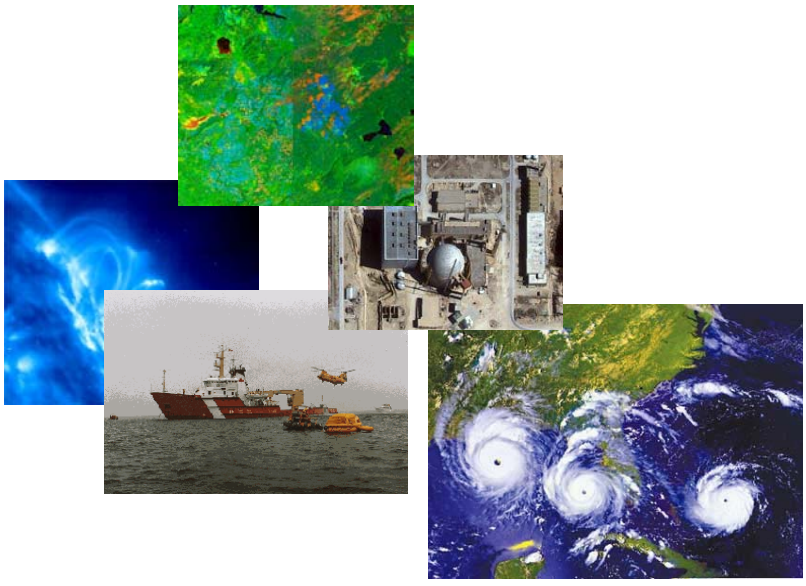
Space and National Security

How Civil and Commercial Space Contribute to Canadian Security



Final Report to the Canadian Space Agency
May 2004

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Executive Summary

The issue of security is today more central to Canadian policy and decision-making than at any time since the Second World War. The direct threat to Canadians at home and to our domestic security is perhaps greater than at any time since Confederation. September 11th, 2001 was a reminder that North Americans could be attacked at home, and that thousands could die at the hands of small, well-organized, well-financed, worldwide terrorist cells. It has crystallized America as a twenty-first century Pearl Harbor, with consequential impacts on our ability to trade openly with and travel to the United States.

The definition of security however is also changing. Once restricted to the traditional geo-political aspects of national sovereignty, resolution of conflicts and protection of national assets, security has taken on a new meaning. Security now provides a common thread for international cooperation that affects many phases of our daily lives and must be considered in a much wider context that includes economic, agricultural and environmental security, and scientific and research components. Under this new definition, Canadian security is also threatened, whether by wide scale pollution of our oceans and waterways, by the depletion of our natural resources and conversion of agricultural lands, or by the retreating habitats of our domestic wildlife, again on unprecedented scales.

This document considers space and security in many forms: intelligence and threat assessment, sovereignty, environmental security, personal and societal security and disaster management on the national level; multilateral treaty enforcement, international relief efforts, foreign policy and international collaborative research on an international scale. In addressing questions of national and international security, a wide range of space solutions are available. Some of these are purely military, while others leverage civil and commercial capability to meet security objectives. In fact, space based assets inherently possess a wide range of dual use applications, but for which civil and defence requirements may be quite different. The focus of this paper is on the contributions of civil and commercial systems to national security.

It is clear from the review of applications that space has a meaningful role to play in all of these areas, and that space and security will remain intimately linked in the coming years. How Canada exploits the opportunities presented by this convergence remains to be determined.

There are a number of important issues that have been identified. The principal issues are:

- the lack of integrated, coordinated systems to respond to security issues;
- the general lack of awareness of space as a strategic and tactical security "tool";
- US versus EU partnership considerations and Canadian dependence on foreign assets for space access; and
- new vulnerabilities created by space system reliance.

As the CSA considers new programs, these should:

- position themselves within Canada's emerging security policy;
- focus on identified areas of Canadian strength and be complementary to the programs of our partners;
- seek partnership amongst our closest allies in each technological sector.

It is suggested that the best approach is to ensure critical capabilities are available and to select a few niches that offer strong contributions to international security systems. In this respect, areas that are particularly promising for future Canadian space security systems include:

- Space-based SAR constellations for wide area, high revisit surveillance of Canada and the world;
- Integrated disaster management ground services and products;
- Integrated space and terrestrial communications solutions for North of 65°.

Canada should also make considerable investments in applications relevant to national security based on foreign sources of readily available data. Targeted investments that offer Canadian users real capability will offer Canada greater international visibility and serve as useful, complementary information sources to allies and multilateral organizations pursuing common security goals with Canada.

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1. Introduction

Security is today more central to Canadian policy and decision-making than at any time since the Second World War. The direct threat to Canadians at home and to our domestic security is perhaps greater than at any time since Confederation.[1]

Picture 1: World Trade Center on September 11th

September 11th, 2001 was a reminder that North Americans could be attacked at home, and that thousands could die at the hands of small, well-organized, well-financed, worldwide terrorist cells. It has crystallized America as a twenty-first century Pearl Harbor, with consequential impacts on our ability to trade openly with and travel to the United States.

Beyond terrorism sponsored by religious extremists and rogue states, a series of new threats to Canadian security have also emerged, including violent secessionist movements, domestic extremism, the proliferation of weapons of mass destruction, failed and failing states, foreign espionage, natural disasters, critical infrastructure vulnerability and global organized crime. In response to the threats, Canada recently tabled its first National Security Policy: *Securing an Open Society*.[2] The National Security Policy (NSP) articulates three objectives for national security: protecting Canada and Canadians at home and abroad, ensuring Canada is not a base for threats to our allies; and contributing to international security.

The scope of security policy is increasingly broader than traditional definitions. Once restricted to geo-political aspects of national sovereignty, resolution of conflicts and protection of national assets, security has taken on a new meaning. Security provides a common thread for international cooperation that affects many phases of our daily lives in a wider context that includes economic, agricultural and environmental security, and scientific and research components. Most civil and commercial applications of space have a dual use application, and military players increasingly look to these assets to provide complementary information sources.

In his introduction to the NSP, the Prime Minister outlined his vision for enhanced national security: "The Government of Canada has taken important steps to respond to this increasingly complex and dangerous threat environment. In the past few years, it has funded over $8 billion in additional investments to address our key security gaps. [I]mportant organizational changes … will further strengthen the capacity of the Government to deal with this new environment. But we need to do more. Working to prevent attacks like the one launched against commuter trains in Madrid requires a more integrated approach to national security -integrated inside the Government of Canada and with key partners. Such an approach will also help us to develop a long-term strategic framework to more effectively prevent and respond to other types of security threats. In short, we need to take the historic step of issuing Canada's first-ever comprehensive statement of national security policy which provides an integrated strategy for addressing current and future threats to our country.[…] Addressing many of these threats requires a coordinated approach with other key partners -provinces, territories, communities, the private sector and allies. […] The measures announced in [this policy] will address important gaps in our system, but the project cannot end here. The Government is determined to build a system that works to continually enhance the security of Canadians and contribute to the creation of a safer world."[3]

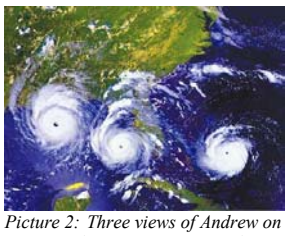
Based on the Universal Declaration of Human Rights adopted by the United Nations in 1948, there is an expectation for "everyone to have the right to life, liberty and the security of person". The United Nations

[1] In the 1860s, Irish independence supporters in the United States, the Fenians, waged regular raids and incursions into Canada, in one instance with as many as 1000 men plundering the Eastern Townships, reinforcing a movement to unite British colonies in North America under one Dominion.

[2] Securing an Open Society: Canada's National Security Policy, April 2004 http://www.pco-bcp.gc.ca/docs/Publications/NatSecurnat/natsecurnat_e.pdf

[3] Ibid.

Development Program notes that security is an "integrative" as opposed to merely a "defensive" concept[4]. Their definition of human security includes seven categories of threats: economic security, food security, health security, environmental security, personal security, community security and political security.

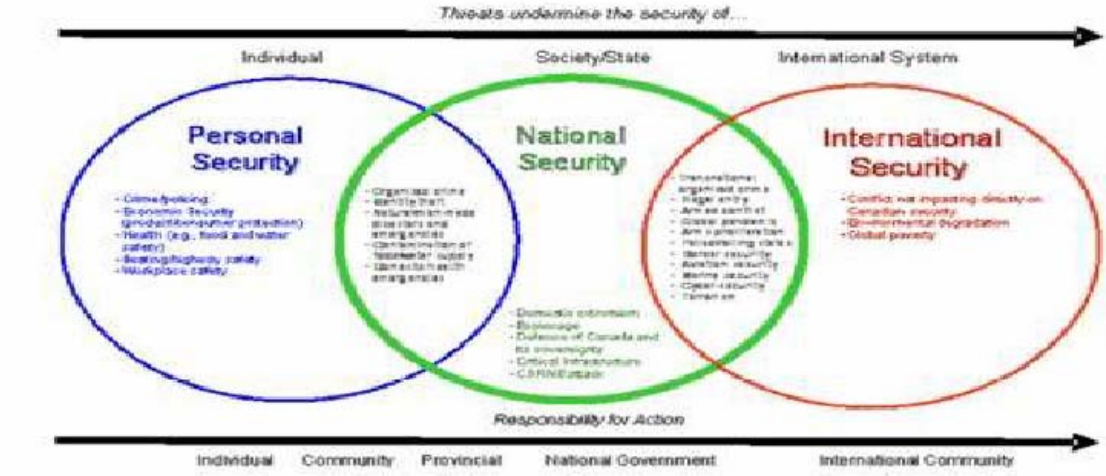


Picture 2: Three views of Andrew on 23, 24 and 25 August 1992 as the hurricane moves East to West.

Whereas security in Canada was once the reserved domain of the national government, many security concerns now directly affect areas that fall squarely within provincial jurisdiction: the environment, forestry, water quality, flooding, and emergency planning and response in support of civil security and disaster management. It is in relation to this broader concept of security that civil and commercial space applications have the most to offer. Space technologies and applications such as satellite communications, remote sensing and navigation technologies and information are powerful tools to address the security challenges facing Canada and the world and provide many new opportunities for the peaceful and secure development of our future. Understanding the technologies, their applications and capabilities, national and international policy considerations, and government to private sector relationships are critical to successful strategic planning and program development activities.

Canada's national security policy encompasses a wide range of activities that straddle individual and international security. The Government of Canada will act as a catalyst with all concerned partners to ensure national security objectives are realized.

Figure 1. The interactions of individual, national and international security



[4] http://www.globalcentres.org/cgcp/english/html_documents/publications/security/eng/intro.html

2. National Security

2.1 Intelligence and Threat Assessment

2.1.1 Direct Assessment and Intelligence

Space based assets have been a major component of the national security equation, specifically for intelligence collection activities on military assets. The reliance on space-based imagery and intelligence gathered was the essential factor in maintaining the balance during the Cold War. However, as new threats such as terrorism, biological warfare, or cyberwarfare have arisen, especially to the superpowers and other Western nations, the role of space imagery in intelligence collection and security is changing.

Picture 3: Ikonos Imagery of Iran Nuclear Reactor Construction, May 2001

Intelligence collection can be divided into three components, strategic, tactical and operational. Space-based assets will continue to play a role in each component. Strategic intelligence derived from space assets, especially for the use of foreign policy development, will continue to be used by large powers such as the United States, Russia, or European states. While the data that can be obtained from many of the commercial assets may be of little value to the larger countries, it does provide a significant strategic improvement for other nations that do not own space assets. Many countries would gain a tactical advantage from the application of intelligence derived from space assets. The planning of peacekeeping missions, United Nations deployments or foreign aid missions can be improved through the use of active use of space based intelligence data. Given Canada's vast international ambitions, a more readily accessible data supply would facilitate many of its activities. While Canada enjoys a good working relationship with the United States, it may have little influence on targeting and timing of data collection it would require for its own intelligence needs. Developing independent Canadian Earth observation (EO) capabilities complements international arrangements rather than competing with them, and increases Canada's ability to develop independent policy on questions of global importance.

Picture 4: Ikonos Imagery of Iran Nuclear Reactor Construction, May 2001

In the event of a major disaster in Canada, such as during the Red River floods of 1997 or the Ice Strom of 1998, space-based intelligence can be of great utility in guiding the Canadian Forces support to the civil power. In these cases, reliable, near-real time access and daily or more frequent revisit are required to allow integration in field operations. The current systems do not offer this, but in future, combinations of systems or new constellations of satellites may offer such intelligence. Operational intelligence to support Canadian missions abroad is discussed in section 3.3.1.

The new NSP identifies the need for objective and continuous assessment of the risks to Canadians based on all available information. Under the NSP, the Government is establishing an Integrated Threat Assessment Centre to provide a comprehensive and timely central assessment capability. Information collected via space assets can constitute a major component of an integrated threat assessment dependant upon the threat being assessed. Being able to collect and integrate this data from the many space sources, both civilian and military, becomes a necessity for the assessment centre to completely fulfill its mandate.

Canada's other primary security departments make less regular use of space-based intelligence as it must be obtained either through the Department of National Defence, through a specific government to government agreement or purchased from commercial sources. A more robust Canadian space capability and better

integration of space and terrestrial information would increase the potential use of space-derived information by these other agencies.

2.1.2 Collaborative Assessment and Intelligence Niches

Canada's closest allies, the United States, the United Kingdom and Australia, have all created threat assessment centres similar to Canada's new centre over the past few years, and greater efforts will be made to collaborate with them in the exchange of information. Canada's centre will enable Government to share and receive all available data, including data derived from allied space-based sensors and observations, as well as internal sources, and make the analysis and results available in an efficient manner.

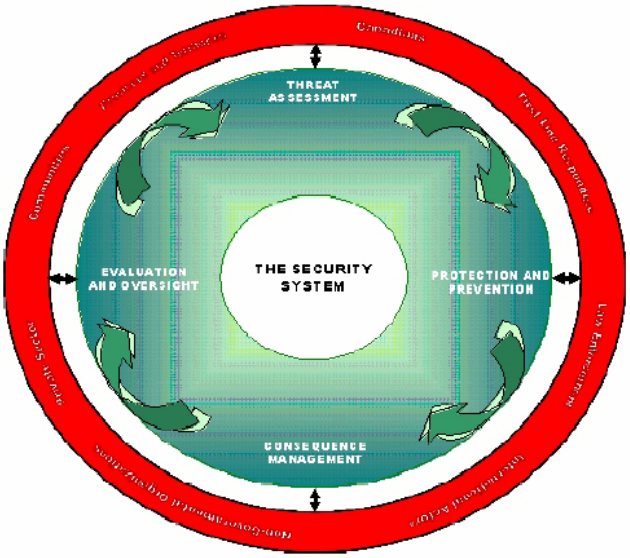


Figure 2: Canada's integrated threat assessment approach

As the variety and specificity of space-based data improves and becomes more widely available, new applications will emerge. With the world dependent on natural resources and agriculture, investors and financial markets may also learn how to better utilize space data for their purposes, especially with the futures markets. Canada is cooperating with allies to ensure assessment of these areas is undertaken in a collaborative fashion.

2.2 Sovereignty

Traditionally, sovereignty has been defined as the ability of a nation to exercise its authority over a given territory. Providing security is protecting the nation's people, its critical national infrastructure and its interests abroad. While this concept has primarily included protecting national territory from unwanted intrusion and restricting access to natural resources, the much broader definition of security that is now accepted must take into consideration many other factors that may jeopardize a nation's sovereignty. While Canada has faced few direct challenges to its sovereignty since the War of 1812, it faces such a challenge in the North today. As climate change brings warmer temperatures to the North, the Northwest Passage may open to increased commercial traffic. Evolution of the traditional concepts of the Law of the Sea have extended sovereign powers to 200 km Exclusive Economic Zones from the former 12 mile rule, and even beyond, as sub-surface ocean floor exploitation rights extend as far as the continental shelf. Understanding where resources lie and protecting our sovereignty over them, particularly in the shallow waters of the North, have become serious issues for the twenty-first century.

Picture 5: Northwest passage

As long as the Northwest Passage remained locked by ice, the interest of foreign nations in this region has been limited. Ships have regularly used it however, often without seeking Canadian permission. Both the United States and the European Union dispute Canada's claim to sovereignty over the Northwest Passage. Canada's case in international law for sovereignty over the Passage appears weak, whether it is based on the argument of "historical internal waters", for which Canada does not meet the applicable test, or on the Passage being icebound for most of the year, as the ice is melting. Should the Passage become ice free, it would likely become a major international oil shipping route between Japan and Venezuela, and Japan and the Gulf of Mexico. General shipping between Asia and Europe and the East Coast of North America

would also likely use the Passage, which is thousands of kilometers shorter than the route through the Panama Canal.

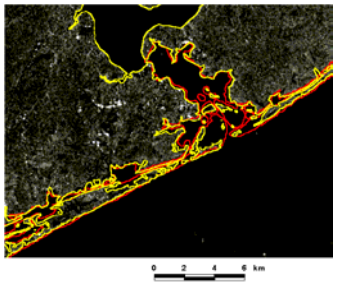
If Canada is intent on asserting its sovereignty, much more information is required about northern activities, and space is an ideal means of supporting limited ground and air-based assets in this effort. If Canadian sovereignty is not recognized, Canada must accept that it does not control vessels – principally oil supertankers - passing through the heart of its most fragile natural ecosystem. In any event, Canada must deal with a host of new challenges facing the North: increased risk of environmental pollution through invasive alien species, waste discharge and oil spills, increased international traffic, with the inherent risk of maritime accidents[5] and generally a greatly increased influx of foreigners in the North, particularly in Iqaluit and Tuktoyaktuk, with corresponding social and economic changes.[6]

Picture 6: Canadian Coast Guard

Access to timely and accurate space asset derived data remains a crucial yet often illusive requirement for Canada. Canada's reliance on US satellite derived data, especially for sovereignty-related purposes, has been and will remain a problem. A similar problem exists with the European Union. How Canada distributes its own data on the North raises similar issues, as Denmark appears to have used RADARSAT data for information on Hans Island and the surrounding waters, a territory actively disputed between Denmark and Canada. Canada has limited ability in influencing acquisition priorities with US military space assets. Canadian RADARSAT data, while accurate and useful, does not always meet requirements for national sovereignty monitoring, especially revisit times, completeness of coverage and accessibility (cost versus need). Other space-based sensing tools such as infrared detectors would be particularly useful in the North given the cold background. The former commander for the Canadian Forces Northern Area states unequivocally that "the most effective way to provide continuous surveillance of the Arctic is through the use space-based assets."[7]

2.2.1 Mapping and Cartography

A key support function with respect to sovereignty is mapping. Much of the Canadian Arctic is not accurately mapped, and producing such maps takes time. The same is true for much of the Canadian boreal North. Mapping Canada's submarine resources and staking our claims under the United Nations Convention on the Law of the Sea (UNCLOS) will require a significant effort with regard to seabed mapping. Claims under UNCLOS must be made within 10 years of ratification, which took place in Canada in the fall of 2003.



Picture 7: Example of the difference between the World Vector Shoreline (data from DND) in red and the contour extracted from RADARSAT data in yellow. Source: EOADP contract with Vantage Point International.

It is technically impossible to enforce our sovereignty over the North without an accurate description of what we are asserting our sovereignty over, and without regular knowledge of how the North is evolving and what is taking place there. Given the low topography, even minor variations in sea levels can cause dramatic shifts in sea levels. Global warming requires regular updates to information to ensure it remains accurate. The sheer scale of the vast northern lands means that space information is the only cost-effective means of mapping areas north of the 51st parallel. Recently, the CSA has begun exploring with the private sector a means of using RADARSAT data to map northern lands to a 50:000 scale. The Mapping and Charting Agency of the Department of National Defence (DND)

[5] The grounding of the cruise ship *Hanseatic* in 1996 demonstrated clearly that Canada is ill-prepared for maritime disaster in these dangerous waters.

[6] An excellent, comprehensive review of the issue of Canadian sovereignty over the Passage and the link to climate change is provided by HUEBERT, Rob, "Climate Change and Canadian Sovereignty in the Northwest Passage" in ISUMA, Volume 2 N° 4, Winter 2001, available at www.isuma.net.

[7] http://www.ccs21.org/ccspapers/papers/leblanc-canada_north.htm

can provide such data for military purposes on an as required basis, and does so in support of Canadian Forces activities in the North. Resources do not however allow for regular mapping of the entire North.

2.2.2 Wide Area Surveillance

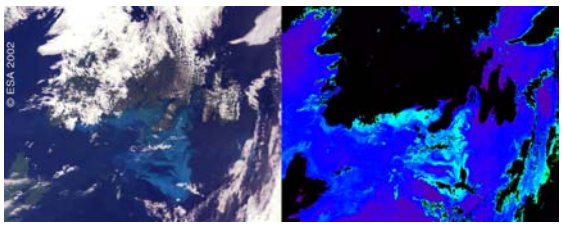
Wide area surveillance is perhaps one of the areas where space has the most to contribute to Canadian security. Canada is the world's second largest country in size, yet has a population of only 32 million people. The overwhelming majority of Canadian territory has an average density of less than 1 person per square kilometer. Given that 87% of the Canadian population is concentrated in urban centres, often closely grouped along the US border, most of Canada consists of wide open spaces where government is largely unable to track movement and changes.

DND's Directorate of Space Development is seeking to exploit space-based information obtained from existing or emerging commercial satellites to contribute to wide area situational awareness along our coasts. Capabilities are being developed that could provide high quality cueing, and possibly classification and motion detection information, for targets over approaches to Canada, over Canada's Arctic region, and in foreign littoral areas where Canadian Forces may be deployed. Canada's RADARSAT-2 is considered a key sensor for such activities. Using space assets, it is possible to regularly monitor ocean approaches and identify ships 500 to 1000 km from Canadian coasts. This "deep interdiction" allows more time to respond and intercept questionable vessels. While space monitoring alone cannot meet security requirements, it is becoming an essential component of an integrated, cost effective approach to wide area surveillance.

2.2.3 Coastal Issues

Similar issues arise with regard to coastline. Possessing the world's longest coastline[8] has posed the greatest recent challenge to Canada's sovereignty. Coastal issues are in a sense a subset of wide area surveillance, but they are characterized by the interaction of two distinct areas: land and water. Our coasts are the point of arrival of illegal immigrants and smugglers, the point of rescue of stranded sailors on sinking boats, areas subject to widespread marine pollution in contravention of Canadian laws, and even a place of near constant change as ice and water erode the coast and operate change on the very structure of our landmass.

Whether it was the Cold War concerns of naval, in particular, submarine movements in Arctic waters, the ongoing international law debate between Canada and the United States on what constitutes international waters and right of passage or the question of illegal fishing, illegal immigration or drug smuggling, monitoring and patrolling Canadian coastal waters is of concern. Access to timely and accurate space asset derived data remains a crucial yet often illusive requirement for Canada. Canada's reliance on United States satellite derived data, especially for sovereignty-related purposes has been and will remain a problem. Canada has limited ability in influencing acquisition priorities with US military space assets.



Picture 8: Phytoplankton monitoring using MERIS off Canada's East Coast

The coastal zone is by its nature dynamic, and space offers a cost effective means of tracking change over time. Use of medium resolution spectrometers such as MODIS or MERIS –"ocean colour sensors" – also allows for monitoring of ocean productivity and water quality monitoring through detection of chlorophyll, dissolved organic matter and suspended inorganic matter. At higher resolutions, sensors can be used to monitor red tides, which present serious health risks to populated areas.

[8] http://atlas.gc.ca/site/english/facts/coastline.html

2.3 Border Security

Besides the longest coastline, Canada also shares the longest undefended border in the world with its southern neighbour. Environmental and natural resource security, as well as law enforcement issues, can be influenced by access to and information derived from space-based assets. The flow of water, in particular with rivers that cross our national boundary and access to Canadian water resources serves as an example of a security issue that would rely heavily on space based data to support and monitor either governmental position. In the disputed ocean zone of the Beaufort Sea, space assets can provide regular information on oil and gas exploration activities.

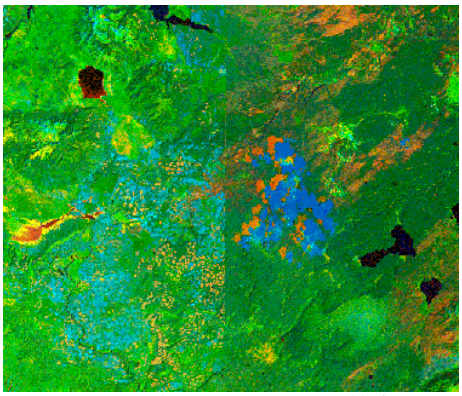
Canada has placed great emphasis in its security policy on Smart Borders. As government streamlines legitimate access to Canada and blocks entry of illegal immigrants and people posing a risk, people will seek new means of entering Canada. Many illegal immigrants have already chosen the sea route. In 1999, several vessels carrying over 120 Chinese were found near a remote western coastal shore.

The wide area surveillance offered by space would allow for deep interdiction by detecting ships as far as 1000 km from our coasts, and dispatching vessels to intervene. Such broad surveillance requires high revisit times, and both the CSA and DND, in cooperation with industry, have been studying concepts offered many satellites and a high revisit of Canada at affordable costs.

2.4 Environmental Security

2.4.1 Environmental Monitoring and Change Detection

Traditionally, most human activities have been undertaken with set purposes, without realizing the extent to which the ecosystems in which they are undertaken are interdependent. In recent years, there is growing awareness that agricultural activities can have a negative impact on water quality in surrounding lakes and rivers, that logging activities can increase erosion and lead to land usage changes or soil deterioration, that mining activities can lead to the introduction of pollutants that affect fish and fauna and ultimately enter food chains that sustain human life as well as numerous animal food chains.



Picture 9: Distinct changes in vegetation, visible from space, mark the western boundary of Yellowstone National Park. Vegetation changes caused by forest clearcuts that occurred between 1972 and 1986 are shown in light blue. Yellow polygons show clearcuts between 1986 and 1992. Vegetation changes following the 1988 Yellowstone fires (orange) also show changes in spectral reflectance.

Understanding these interactions and tracking changes in specific data sets and determining correlations are critical steps to our ensuring that the environment we enjoy is passed on to our children and children's children.

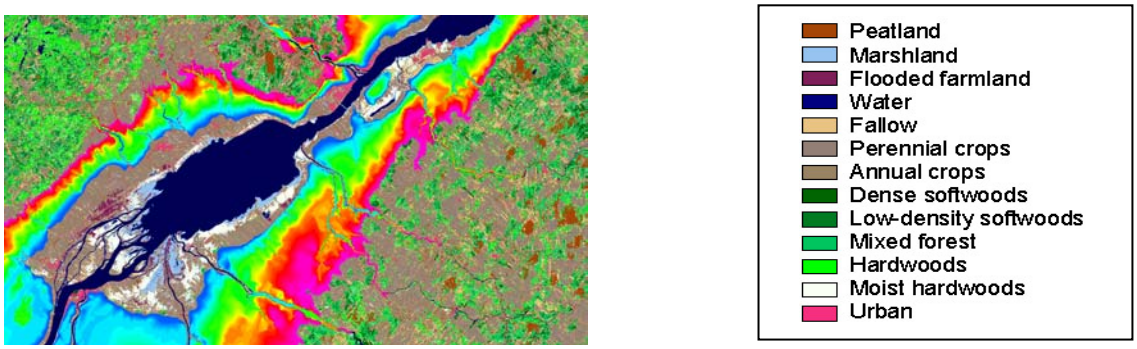
Having access to space data from a variety of sensor platforms such as panchromatic, multi-spectral, hyper-spectral, passive micro-wave and radar offers the unique scope and coverage to monitor such changes on a very large scale, both nationally and globally. Furthermore, continued participation in the variety of international programmes, as well as work on interpretation and analysis remains the key to environmental monitoring.

Canada's RADARSAT has been used for years to detect and monitor oil spills and water pollution, but much remains to be done to explore how different satellites can work together to examine entire inter-linked systems and the changes that cause other changes.

In the future, space-based hyperspectral data may be used to accurately monitor changes to land-cover that are indicative of environmental pollution or contamination.

2.4.2 Wildlife and Natural Habitat Monitoring

Environmental security depends in part on our ability to monitor and protect Canada's wildlife and flora, and the habitats that sustain them. With over 9 million square kilometers of land area, tracking the evolution of habitats, or even mapping them and linking them to specific animal populations, is a challenge. Space offers a broad perspective to classify these habitats and monitor changes that are likely to have an impact on wildlife.



Picture 10: St-Lawrence Valley Wetlands Mapping and Classification Using Space Data. Using various sources (RADARSAT and Landsat in this example) detailed classifications of coastal regions and wetlands can be achieved to identify long-term trends and to support integrated management initiatives.

2.4.3 Sustainable Resource Management

Reliable information on Canada's resources is critical to our on-going ability to manage them in a sustainable fashion. Whether in relation to forestry, water, agriculture, energy, fisheries, mining or other areas, Canadian resource development requires comprehensive information about quantity and quality of the resource, and about the interactions between the resource and related environmental systems.

A number of Canadian organizations are playing lead roles in exploring how space can be brought to bear in support of this objective. Some examples include:

- The Pacific Forestry Center and Canada Centre for Remote Sensing (CCRS) are using space data to map burned areas of forest and track land cover evolution.
- Agriculture and Agri-Food Canada has begun exploring how to use space data to monitor agriculture lands to track soil moisture, to maximize fertilizer usage and limit over exploitation of soil, contributing to food security.
- CCRS and the CSA are exploring how the use of hyperspectral data can be used for a wide array or resource related applications that affect environmental security and sustainable development and exploitation of mineral resources.
- CCRS is using Landsat data to map forest cover in Canada over time to produce sustainable development indicators.
- Medium resolution spectrometers are frequently used by Fisheries and Oceans Canada and other agencies to monitor water quality and track fisheries.

Picture 11: Percentage of forest cover in Canada used as environmental indicator

Increasingly, resource managers are becoming aware of the value and thus dependent on space-based information to ensure the sustainable exploitation of our natural resources.

2.5 Transportation Security

The development of the Global Positioning System (GPS) by the United States military, and now with its extensive civilian applications is the dominant space based asset, especially in the transportation sector. The reliance on GPS by nearly all of the world's airline industries, as well as for navigation and asset tracking in the surface transportation and marine transportation sectors makes it an indispensable asset. GPS also plays an essential role in policing, dispatching (taxis and ambulances), and search and rescue activities in many countries, especially in Canada, where its large, yet relatively unpopulated land mass greatly benefits from the information derived from GPS. Reliance on a single system, owned and operated by a single foreign government, may appear as a vulnerability, but as long as Canada remains allied with the United States, and maintains its active role in NATO, this is not a serious concern. The development of the European Galileo system will soon offer commercial services that can serve to complement GPS, even though the two systems are not truly interoperable. Canada is a participating nation in the Galileo system and Canadian industry will supply certain system components.

Given Canada's long coastline, vast, northern, ice-infested waters and the joint management of the St-Lawrence Seaway and Great Lakes marine traffic, maintaining watch over shipping routes presents a significant security challenge. Whether the threat is to the environment, such as bilge cleaning or illegal fishing, or to Canadian safety, such as terrorist activity or weapons smuggling, integrated marine management would benefit greatly from increased integration of space assets. In support of environmental enforcement activities, the Canadian Space Agency's Government Related Initiatives Program (GRIP) is funding a new effort to develop operational monitoring of marine polluters to support environmental enforcement activities: Integrated Satellite Targeting of Polluters (I-STOP). Using RADARSAT data validated with data from traditional aerial resources, the project improves government action targeting polluters on Canada's east and west coasts and in the Gulf of St-Lawrence. Future extension of this program to the Arctic should be envisaged given the increased traffic in this sensitive environment. This Government of Canada project is undertaken jointly with the CSA, Environment Canada, Fisheries and Oceans Canada/Canadian Coast Guard, DND, Transport Canada, and the private sector's RADARSAT International.

However, a comprehensive, operational system would require far greater coverage of Canada and its approaches. Constellations of up to six satellites have been studied, optimized to offer twice daily coverage of Canada and three times daily coverage in some critical areas. Such blanket coverage offers a solid backdrop for an integrated marine management system that provides deep interdiction off Canada's three oceans and regular tracking in the Great Lakes-St-Lawrence System.

Under the NSP, the government aims to increase aerial and on-water marine surveillance by the Canadian Forces, the RCMP, the Coast Guard and the Department of Fisheries and Oceans. One effective means of achieving this is to integrate satellite tasking of these resources to optimize their use.

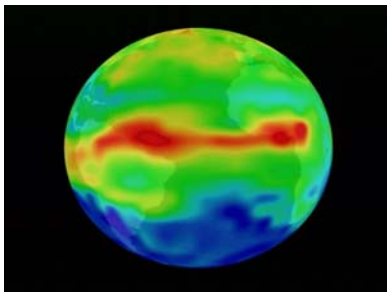
Public Safety and Emergency Preparedness Canada (which encompasses the former Office for Critical Infrastructure Protection and Emergency Preparedness) recently announced the acquisition of large volumes of Ikonos commercial satellite imagery to create a data base of Canada-US border crossings as viewed from space. This provides another example of the use of space for identification of critical infrastructure in support of security applications. In fact, Canada is increasingly using satellite images and data to support predictive computer models that help better anticipate and respond to events such as storms, flooding and other disasters that can impact infrastructure.

2.6 Personal and Societal Security

Social security encompasses many facets of our daily life or role in a community, often without the realization that a space-based asset plays an integral role. Furthermore, the reliance is increasing and spreading into new areas. Earth observation technologies can provide support to certain public health emergencies and law enforcement. However, social security is probably most dependent upon GPS, and the telecommunications industry, which facilitate the flow of information in our information intensive society.

2.6.1 Public Health Emergencies

Space technology also offers a unique perspective on some of the most dangerous threats to security: chemical, biological, radiological and nuclear contaminants. Canada has been a world leader in ozone monitoring, as well as pollutant monitoring in the lower atmosphere. This image is a colour-coded image (based on MOPITT satellite data) depicting carbon monoxide concentrations. Using similar technology, DRDC-Valcartier has developed an instrument to detect chemical, biological, radiological and nuclear (CBRN) contaminants. The CSA and DRDC are currently studying the possibility of flying this instrument in space. Other technology developed through the atmospheric science program allows accurate wind tracking and prediction, meaning contaminant behaviour could be predicted, allowing disaster managers to follow the infamous "death" cloud once a disaster has occurred.



Picture 12: The Earth viewed by MOPITT, showing carbon monoxide concentrations.

Given a recent rise in concerns of bio-terrorism on a global basis, space assets offer a basic understanding of wide area behaviour of contaminants, and serve as a useful complement to in-situ and aerial resources deployed in the event of an emergency.

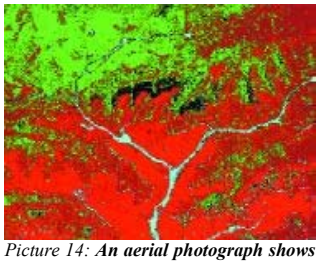
2.6.2 Healthcare and Education

As Canada continues its pursuit of linking all corners of the country through the Internet, and promoting the information age, health and education are two sectors which offer areas of continued growth and improved security for its population. In both cases, the requirement for an integrated, cross-country communication system which allows the opportunity to access the best available expertise, regardless of where the need is, will continue to be a necessity for Canada. While land-based fiber optic networks will probably supply sufficient broadband communications between larger urban facilities, space-based communications remain essential to linking the smaller and more remote communities. With the emergence of "telemedicine" as a new area of development, the ability to provide medical expertise remotely will certainly help Canadians in remote regions. As diagnosis and possibly even remote surgery becoming a reality, the existence of a reliable, broad band space based communication system to support the health functions will remain an ongoing requirement. Similarly, providing an enriched education throughout the country, in particular to remote areas, is a promising opportunity for Canada. Canada could propel itself into a world leader in these areas by supporting research and infrastructure to support these areas.

Picture 13: telemedicine workstation

2.6.3 Policing and Enforcement

Police services have begun to use space-based information, particularly GPS services to track stolen vehicles and even to monitor certain movements of criminals. In the US, GPS based tracking is used in at least 28 states in over 2,500 cases to monitor the movements of sexual predators.



Picture 14: ***An aerial photograph shows a suspected marijuana "farm" in the United States, along with forests, licit row crops, upland crops and roads. The multispectral digital imaging system (MDIS) allows investigators to differentiate among the crop types present in the area, showing marijuana plants in black.***

In BC, an experimental drug enforcement program examined the use of Ikonos data for marijuana farm identification, but eventually decided the cost of data acquisition made the system unsustainable and may raise issues under the Canadian Charter of Rights and Freedoms in relation to privacy. In general, the use of commercial imagery in policing and enforcement is limited by the timeliness of the data.

Increasingly, organized crime in Canada is becoming a part of a global network that links many criminal activities, including the drug trade, smuggling of illegal immigrants, weapons trade and terrorism. Many of these activities may be, in part, be monitored more effectively through the use of space based sensors. Whether commercial sensors provide part of the solution would still be under debate, but undoubtedly, any coordinated policing and law enforcement agency or activity would benefit from data and information received from space based assets.

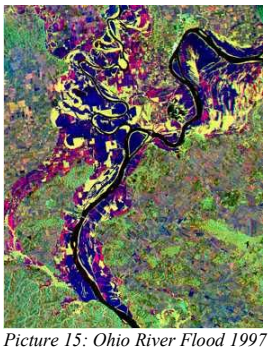
2.7 Disaster Management and Critical Infrastructure Protection

At the heart of security of Canadians lies the issue of disaster management. When natural or man-made disasters occur, Canada must be prepared to have in place an effective, integrated disaster management system that has access to the full potential of space-based assets to respond in a timely and coordinated fashion. In fact, space data and information can be used in every aspect of the disaster management cycle, from preparation and early warning through mitigation and relief and damage assessment and prevention. Space assets now allow countries to monitor weather, follow environmental degradation progress, and in many cases reduce the damage and human loss with accurate advanced notification. As with many natural disasters that can not be predicted, the use of space based monitoring and assessment can greatly aid the recovery process and limit the damage.

Under the NSP, Canada is establishing a new Government Operations Centre to provide stable, around-the-clock coordination and support across government to key national players. Where practical, the government is committed to co-locating federal resources with provincial, territorial and municipal emergency measures operations centers. These centres require a solid understanding of and regular access to space-based EO and communications capabilities, products and services.

Figure 3: Disaster management cycle

2.7.1 Preparation and Early Warning



Picture 15: Ohio River Flood 1997

Space data is particularly useful for the early warning of weather-related disasters such as hurricanes and monsoons. Canada's Hurricane Watch program uses RADARSAT data to study the eyes of hurricanes for future research into hurricane behaviour. Space data are now essential for most hurricane warnings, and are used to predict severity and landfall information.

Interferometry is currently being used to investigate the possibility of using space sensors for early geohazard detection such as earthquakes and landslides, but this work is still at a research stage. The United staes Air Force (USAF) designed Quakesat is a passive detector that monitors changes in radio emissions before earthquakes.

In India, space communications are used to send warnings to remote areas and coastal zones likely to be affected by heavy storms, in order to ensure timely evacuation notices are given.

In Canada, RADARSAT data can be used to track water levels and warn of flooding, except in cases of flash floods.

2.7.2 Mitigation and Relief

The use of space data for operational relief efforts is more challenging. From an EO point of view, this requires regular revisits of the affected area, at least once a day, and relatively high resolution to identify affected infrastructure and homes. From a communications point of view, once obtained, the information must be communicated in the field to disaster relief workers who require timely information to save lives. Often maps made before the disaster cannot be properly used, as the landscape may have changed and hazards are not properly identified. Terrestrial communication systems are often out of order and space communications offer a unique means of communicating between workers. Geographic Information System (GIS) models of affected areas can help coordinate relief efforts amongst various organizations and ensure that those saving lives work with those rebuilding critical infrastructure or ensuring food and water distribution. Some of these needs may be best met by aerial support, but this is not always available and may be costly. Space, safely removed from the affected zone, yet uniquely present through line of sight communication and cloud penetrating radar, may offer the most robust means of support disaster relief, provided critical issues such as revisit and cost of infrastructure are resolved. In any event, it offers useful complementary information to other available sources.

The CSA is currently cooperating with the European Space Agency (ESA), the French Space Agency (CNES), the US National Oceanographic and Atmospheric Administration (NOAA) and the Indian Space Research Organisation (ISRO) in the context of the International Charter Space and Major Disasters. Countries affected by major disasters may invoke the Charter and receive free RADARSAT data and data products in support of immediate relief efforts, as well as data from a host of foreign satellites.

2.7.3 Damage Assessment

Damage assessment is currently the most common application made of remote sensing information, because it is the least time critical element of disaster management and consequently less dependent on timely revisits of the affected area. However, even damage assessment must be accomplished in the days following the disaster. Reliance on a single space asset, even if not acutely critical in the disaster management scenario, can be troublesome. For example, until recently, both Landsat 5 and 7 data was used in the United States to monitor the effects of fire damage. The recent hardware problems with Landsat 7 means that the revisit time for a given area has doubled to sixteen days, yet assessments must still be made

within 7 days in order to clear the way for federal funding to support disaster relief. As a consequence, space data may no longer be able to support this operational requirement unless backup or duplicate system access is available and made interoperable.

Insurance companies in Europe, the US and Canada use space imagery for damage assessment, both to verify the extent of claims, to estimate overall liability in the immediate aftermath of disasters and to track historical trends and establish risk level by area and potential exposure to liability.

2.7.3 Critical Infrastructure Protection

Canada's critical infrastructure consists of 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. The Canadian critical infrastructure is said to be made up of ten (10) sectors:

1. Energy and Utilities (e.g. electrical power, natural gas, oil production and transmission systems);
2. Communications and Information Technology (e.g. telecommunications, broadcasting systems, software, hardware and networks including the Internet);
3. Finance (e.g. banking, securities and investment);
4. Health Care (e.g. hospitals, health care and blood supply facilities, laboratories and pharmaceuticals);
5. Food (e.g. safety, distribution, agriculture and food industry);
6. Water (e.g. drinking water and wastewater management);
7. Transportation (e.g. air, rail, marine and surface);
8. Safety (e.g. chemical, biological, radiological and nuclear safety, hazardous materials, search and rescue, emergency services, and dams);
9. Government (e.g. services, facilities, information networks, assets and key national sites and monuments);
10. Manufacturing (e.g. defence industrial base, chemical industry). [9]

All of these sectors may possess a space component. To provide examples for a few, the financial community relies on the timing signals generated from GPS to record national and international financial transactions. Telecommunications, especially to remote areas of Canada, rely on satellite-based communications and are essential for ensuring all communities in Canada have access to information and government services. Nearly all aspects of the safety sector have a space component whether it be surveillance, communications or positional information.[10]

[9] http://www.ocipep.gc.ca/critical/index_e.asp#dams

[10] A report on Canada's National Space-based Vulnerabilities was prepared in 2003 for the Department of National Defence by Lansdowne Technologies Inc., Athena Global and Electronic Warfare Associates.

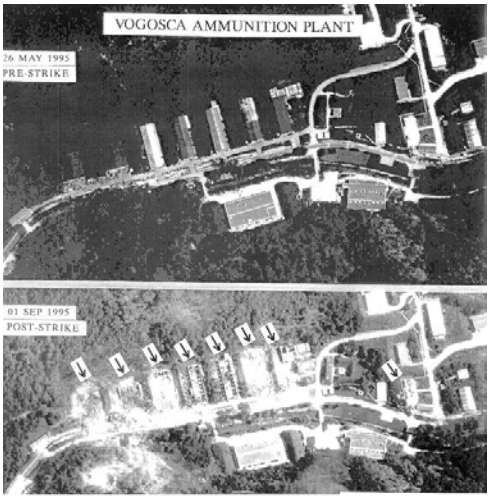
3. International Security

Canada works with its allies to contribute to international security. This is increasingly considered to encompass unilateral, bilateral and multilateral activities contributing to the three "D"s: defence, diplomacy and development.

3.1 International Defence

3.1.1 Operational Support for Direct Action

Peacekeeping requires a large volume of situational information and operational support due to the presence of hostile forces. Canada, generally represented by the Canadian Forces, has historically played a major role in peacekeeping operations for the United Nations. Increasingly, significantly improved situational awareness on countries of prospective deployment is required. Currently, Canada relies on significant amounts of information, especially space-based information, received from allies. Space information and specific applications designed to integrate vast amounts of different data for specific needs can provide unique support to Canadian troops abroad. Access to Canadian space-based data would enhance Canada's ability to serve as effective peacekeepers.



Picture 16: Satellite images pre and post strike in 1995 Bosnian campaign – Vogosca Ammunition Plant


Picture 17: Canadian Forces on Peacekeeping Mission

For operational intelligence, Canada must exclusively rely on other countries for space-based information collection, even if Canada has a senior commanding role in an operation. Canada's lone asset, RADARSAT has many competing priorities, including remaining financially viable, that limits its use as an intelligence collecting source.

3.2 Foreign Policy and Diplomacy[11]

3.2.1 Monitoring in Support of Policy Objectives

The need for information is not however limited to troops abroad. In all cases, foreign policy decisions are tributary to information available about specific situations. Whether this information concerns internal movements of people, the environmental condition of a natural forest or body of water, the presence of banned facilities or some other information, Canada is more often than not dependent on international media or foreign allies to provide such information. This method does not protect Canada from potentially biased or incorrect data. Access to its own space-based information can provide a reliable means of verifying this information, and in some cases may prove to be the only independent source for Canadian decision makers.

3.2.2 Disarmament and Non-proliferation

While it is not possible to use space data and technologies for all aspects of disarmament and non-proliferation verification, remote sensing data remains one of the best ways of discovering banned activities

[11] See SANDALOW, supra.

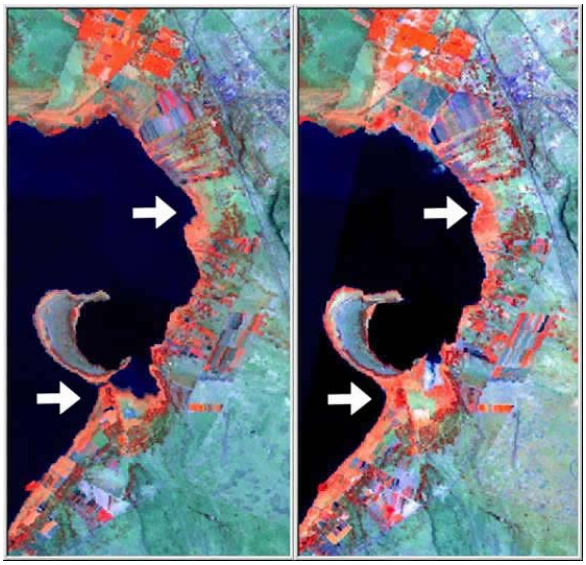
involving nuclear production and refining of nuclear waste for weapons of mass destruction. High resolution sensors from military satellites are routinely used for security purposes by Canadian allies to identify potential threats and monitor them, most recently in Iran and North Korea. The use of commercial imagery for these purposes has not yet become widespread.

Intelligence collection activities have now expanded beyond traditional national security concerns. Other international organizations now also have a legitimate use for intelligence collection, including information derived from space based assets for monitoring and compliance purposes. Organizations such as the International Atomic Energy Agency (IAEA) or the Chemical Weapons Convention can greatly benefit from the intelligence derived from space-based assets.

The difficulty is that these organizations do not own any space assets, and must either purchase data/ or imagery from commercial sources, or rely on member states providing the information from their own assets. With the increasing number of commercial satellites that can provide a variety of space data, ranging from panchromatic to multi-spectral and radar imagery, these organizations have a wider choice and opportunity to use the assets. If Canada had either more space assets, or more control over its current assets, it could provide more intelligence and security data for its roles in these international organizations. Other international organizations that similarly benefit from the intelligence and security data could be foreign aid groups (i.e. Red Cross) and the various United Nations organizations.

3.2.3 Environmental Treaty Monitoring[12]

The number of treaties governments have signed and must enforce or monitor in relation to the environment is growing at a tremendous rate. In the US, the Bureau of Oceans and International Environmental and Scientific Affairs, supports over 180 such treaties and conventions – nearly triple the number of 1992 - on issues as broadly ranging as the 1946 International Whaling Commission, the 1975 Ramsar Convention on Wetlands, the 1982 UN Convention on the Law of the Sea, the 1987 Montreal Protocol to the Vienna Convention for the Protection of the Ozone Layer, the 1989 Basel Convention on Transboundary Movement of Hazardous Waste, the 1992 Convention for the Conservation of Anadromous Fish in the North Pacific Ocean and the 1994 UN Convention to Combat Desertification.



Picture 18: Lake Naivasha, Kenya. Landsat imagery from January 1986 (left) and February 1987 (right). Lake Naivasha supports a diversity of natural and human activities and was one of the Ramsar Wetland Conservation Award winners in 1999. The dramatic change between the two Landsat images, taken 13 months apart during the growing season, may be related to natural fluctuations in the hydrologic cycle. These images demonstrate the importance of understanding the environment when defining a significant threshold of change.

There are a number of challenges to be addressed before remote sensing can offer significant contributions to multilateral environmental treaty enforcement, but these can and will be addressed. They include: demonstrating to the environmental diplomatic community the potential benefits and relevance of remote sensing, identifying priority treaties where remote sensing can be most readily applied, fostering active dialogue between remote sensing scientists and the foreign policy community, and identifying international guidelines for the development of remote sensing procedures, standards and data formats for integration of data into the negotiation and implementation of treaties.

[12] See SANDALOW, David B., US Assistant Secretary of State for Oceans and International Environmental and Scientific Affairs, "Remote Sensing and Environmental Treaties: building more effective linkages", workshop presentation 4-5 December, 2000

In Canada, significant work has been completed to establish algorithms and applications for Ramsar Convention monitoring under contract to the European Space Agency. Building on such successes will allow Canada to take advantage of further opportunities in this promising area.

3.3 Development

3.3.1 International Humanitarian Relief

Space information is particularly useful in situations involving international relief, which are often in war zones or in areas affected by catastrophic events. In these situations, when infrastructure is damaged or otherwise unavailable. Space assets can be readily brought to bear and provide the sole means of assessing the situation and supporting operations.

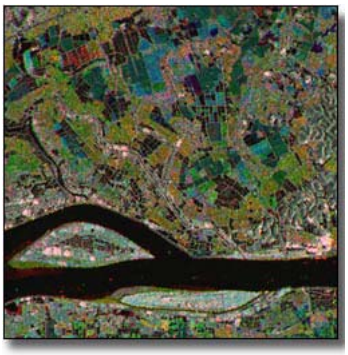
The most urgent need in critical situations is to understand the exact nature and extent of the problem. This situational awareness need is often met by remote sensing information using satellites. In Canada, DND used RADARSAT data to study refugee movements in Rwanda and the Lakes District in Central Africa in the 1990s. The United Nations High Commission for Refugees (UNHCR) uses space data on a regular basis to obtain information about crises and make estimates of the numbers of refugees and likely needs before preparing their missions. In some cases, GIS-referenced space data has been used to manage camps. However, like with policing and law enforcement, timeliness of the data can be limiting.

Picture 19: Ikonos image of Beldangi refugee camp in Nepal

Once a support mission is decided, space assets can provide a vital link to the rest of the world. Satellite phones often offer the only reliable means of communication, and now offer data transmission as well. GPS encoding on maps and GIS systems allow humanitarian relief organizations to organize their activities with a precision and detail previously impossible. In African refugee camps, UNHRC has used GIS to map down to individual families and monitor evolving needs for sanitation, food and other basic necessities.

In Canada, the Canadian Red Cross is mandated by CIDA to provide operational support for International Humanitarian Assistance in the event Canada offers support to a foreign nation in need. Similarly, DND is called upon on occasion to intervene in difficult circumstances and could benefit from broader access to space-based information and tools.

3.3.2 International Development Assistance



Picture 20: Rice crop monitoring in China using Radarsat data

Space-based EO data, as well as satellite communications, are now regularly used by international development agencies such as the United Nations Development Program (UNDP) and the Food and Agriculture Organisation (FAO) in support of development projects around the world. The main areas of use include crop monitoring and prediction (rice in Asia and cereals in Africa), desertification monitoring in Africa, deforestation monitoring globally, and water source identification in Africa and Asia. In the developing world, both India and China have pioneered the use of space in support of national development priorities.

3.4 International Collaborative Scientific Research

Collaborative research encompasses research in space, atmospheric research or the use of space assets for terrestrial research. Yet Canada with its long history in space-related research, and active collaboration in many international projects may still not be viewed as a major player, emerging player or first choice collaborator, as evidenced by a recent European report on the future of EU space collaboration.[13]

There are many areas of international science research that are relevant to security. The main ones retained for further consideration were climate change research, solar-terrestrial research and asteroid and foreign object detection.

3.4.1 Climate Change Research

Until recently, climate change research seemed to have little relevance to security questions. It is now better understood that climate change impacts such as desertification cause dramatic changes in the developing world, which can increase economic strain and produce large scale migrations and in general greater instability.

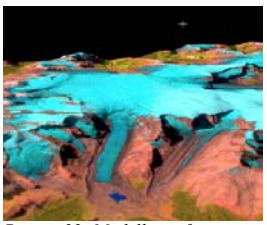
Picture 21: Sudden dramatic climate change can have devastating impact as shown by this image of recently rich and fertile land in sub-Saharan Africa

It has also been demonstrated that global warming has increased the number and frequency of extreme weather events. These events are often the source of disasters such as flooding which can cause loss of life and serious damage to property.

More recently, climate change scenarios have begun to deal with the prospect of rapid or abrupt climate change. In a recently completed study[14] presented to the Pentagon, the concept was developed based on historic data from Greenland ice cores considering the past 15 thousand years. Similar conclusions are yet to be reached using modeling techniques based on data from recent changes in the high Arctic, however, the concept is not incompatible with a dramatic cooling of the Gulf Stream caused by melting Arctic ice. The dramatic results show that a major change in global temperature, and related rise in global sea levels, could take place over less than ten years, rather than the previously believed century or more. A dramatic rise in sea levels would affect major industrialized nations and threaten coastal infrastructure. In the North, and in low-lying coastal areas globally, a rise in sea levels will change coastlines and cause property damage. Extreme weather events also accelerate coastal erosion and rapidly change coastlines.

Canada has played and continues to play an active role in studying and reporting on the effects of climate change. It has taken a leadership role as a member of the Integrated Observing Strategy Partnership (IGOS-P), as well as active roles in the internationally agreed global observing systems for climate and terrestrial observation, GCOS and GTOS. Canada is expected to play an important role in a number of key areas, including the space component, provision of information and leadership on scientific and technological aspects of earth observation.

The Meteorological Service of Canada works both internationally and with the Canadian university community to develop models for climate change and develop sensors that generate useful data for inclusion in these models. "Cryosphere and its Response to Climate Change" is led by the Meteorological Service and supports activities focused on the development of the operational use of satellite data to monitor and understand variability in cryospheric elements and their response to changes in climate. It is linked with the Canadian project "Cryosphere System in Canada", or "CRYSYS", a collaborative research effort by Canadian government agencies and universities



Picture 22: Modelling of Canada's cryosphere based on space and in-situ data

[13] http://europa.eu.int/comm/space/whitepaper/pdf/whitepaper_en.pdf

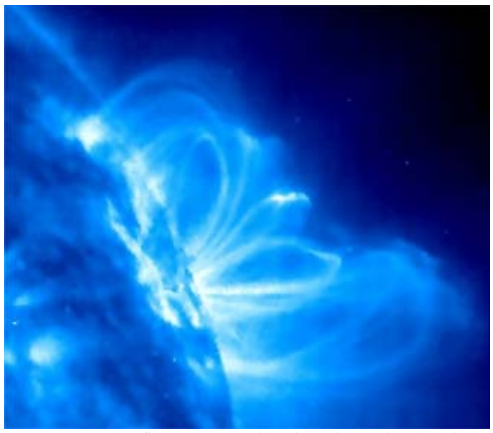
[14] SCHWARTZ, Peter, RANDALL, Doug, *An Abrupt Climate Change Scenario and Its Implications for United States National Security*, commissioned by the U.S. Defense Department, October 2003 http://www.ems.org/climate/pentagon_climatechange.pdf

that is also led by the Meteorological Service of Canada. CRYSYS has been an Interdisciplinary Science Investigation in NASA's EOS program since 1990. Other programs exist at CCRS to monitor and document the impacts of climate change on Canadian ecosystems.

3.4.2 Space Weather and Solar-Terrestrial Research

Space weather, caused by solar flares interacting with our upper atmosphere, has been found to have a negative impact on satellite activity as well as wreaking havoc on northern power grids. In recent surges of solar activity, satellites have been lost, including a major EO satellite owned by Japan (ADEOS-II). Given the growing dependence on space assets for security, the loss of EO, communications or navigation satellites can have a dramatic impact on security and cost nations billions of dollars.

Understanding solar-terrestrial relations and devising means to mitigate its effects may be critical to protecting our assets in the future.



Picture 23: Solar flares as viewed by the Solar and Heliospheric Observatory (SOHO).

The international solar terrestrial science community has come together to study Sun-Earth relations and "space weather", the phenomenon created by the interaction of solar plasma with the upper atmosphere. This collective enterprise is called International Living With a Star. Through science and cooperation, the project endeavours to stimulate, strengthen, and coordinate space research to understand the governing processes of the connected Sun-Earth System as an integrated entity. Canada plays a key role as lead for ground segment activities in this effort involving over 40 countries over 14 years. Recent work has indicated that space weather may be related to global warming.

Canadian GeoSpace Monitoring is motivated by the recognized need for greater fundamental understanding of planetary environments that are affected by short and long term variability of our star: the Sun. The Sun and Earth form a tightly coupled system, with solar variability driving effects on space weather and climate, the creation of harsh radiation environments and the generation of the aurora. This program seeks to understand this fundamental solar-terrestrial coupling and its influence on our planetary environment.

3.4.3 Asteroids and Other Earth-intercepting Object Threats

The Earth has in the past witnessed cataclysmic collisions with asteroids. In recent history, astronomers observed the break-up and collision of the comet Shoemaker-Levi with Jupiter. While not common, such cosmic events do occur and the consequences of such a collision would be disastrous for Canada and the world. It is widely believed that a large asteroid impact was the trigger event of the extinction of the dinosaurs millions of years ago, along with 55% of other life forms on Earth. There have been several cataclysmic collisions with asteroids since the Earth formed, each likely capable of eliminating human life on the planet if unchecked.

Smaller objects, while representing a much less serious threat to humanity, can nonetheless cause

significant damage on local scales, and are much more common. An object of dense material about 100m in diameter entering the atmosphere in Tunguska, Siberia in 1908 exploded with a force of over 12 megatons, flattening trees for kilometers around and causing a shockwave that went around the world twice. It left traces of devastation visible in the Siberian forest to this day. US astronomer Eugene Shoemaker, who gave his name to Shoemaker-Levi, made considerable efforts to estimate the likelihood of such asteroid impacts on Earth. While a 100m diameter asteroid such as the one that likely caused the Tunguska event would appear every 300 years (within a factor of two), smaller meteorites causing 20 kiloton explosions enter the atmosphere every year.[15]

The observation of space also can be applied to monitoring the status of the various man-made space objects orbiting earth. Canada has had two occasions where a Russian satellite or a failed booster rocket has entered the atmosphere and crashed on to Canadian soil. The use of space-based assets can be valuable in the monitoring of space objects, as well as in clean-up or recovery activities.

Canada has recently begun exploring participating in the survey of near Earth space in order to offer early warning. This is accomplished by studying objects in long-term orbit around our sun – essentially asteroids and comets- and predicting their trajectories. The CSA and DND have jointly initiated a study to develop the capability of monitoring near Earth objects and satellites in higher orbits using a single satellite platform.

[15] http://www.totse.com/en/technology/space_astronomy_nasa/tungusk2.html

4. The Players and their Roles

4.1 New Players and Institutional Changes

4.1.1 Public Safety and Emergency Preparedness Canada (PSEPC)

On December 12, 2003, Prime Minister Paul Martin announced the creation of the new portfolio of Public Safety and Emergency Preparedness. It includes emergency preparedness, crisis management, national security, corrections, policing, oversight, crime prevention and border functions. Six agencies report to the minister: the Royal Canadian Mounted Police, the Canadian Security Intelligence Service, the Correctional Service of Canada, the National Parole Board, the Canada Firearms Center and the Canada Border Services Agency. As well, the Office of Critical Infrastructure Protection and Emergency Preparedness was integrated into the new department, having formerly been part of DND.

4.1.2 The Royal Canadian Mounted Police (RCMP)

The RCMP is the Canadian national police service and an agency of the Ministry of the Solicitor General of Canada. Its task is to prevent and investigate crime, maintain order, enforce laws on matters as diverse as health and the protection of government revenues, contribute to national security, ensure the safety of state officials, visiting dignitaries and foreign missions, and provide vital operational support services to other police and law enforcement agencies. The RCMP maintains constables in most isolated northern communities, making them a critical component of northern security strategies. They are also the frontline of disaster response in much of rural Canada, and play a lead role in investigating and fighting organized crime and drug trafficking.

4.1.3 Canadian Security Intelligence Service (CSIS)

CSIS is a government agency dedicated to protecting the national security interests of Canada and safeguarding its citizens. The main objective of the Service is to investigate and report on threats to the security of Canada, an objective that it pursues while respecting the law and protecting human rights. CSIS is unique in its role as the Government of Canada's principal advisor on national security.

4.1.4 Canadian Border and Security Agency (CBSA)

The CBSA brings together all the major players involved in facilitating legitimate cross-border traffic and supporting economic development while stopping people and goods that pose a potential risk to Canada. It integrates several key functions previously spread among three organizations: the Customs program from the Canada Customs and Revenue Agency, the Intelligence, Interdiction and Enforcement program from Citizenship and Immigration Canada, and the Import Inspection at Ports of Entry program from the Canadian Food Inspection Agency.

The CBSA's role is to manage the nation's borders by administering and enforcing about 75 domestic laws that govern trade and travel, as well as international agreements and conventions. Their joint efforts with the United States have led to the establishment of integrated border and maritime enforcement teams as well as establishing joint intelligence assessment centres.

4.1.5 Critical Infrastructure Protection and Emergency Preparedness

Canada's critical infrastructure constitutes the backbone of our national economy and fabric and is essential to the health, security, safety and economic well-being of Canadians and to the effective functioning of governments. As a key enabler to the modern economy, it is complex, inter-connected and inter-dependent

and relies heavily on information technology. Disruptions in one infrastructure could produce cascading disruptions across a number of other infrastructures -- with significant economic and social consequences.

CIPEP is also the government's primary agent for ensuring national civil emergency preparedness. Our mandate under the Emergency Preparedness Act is to safeguard lives and reduce damage to property by fostering better preparedness in Canada. They have recognized the need for timely and accurate space based data to carry out their mission and have a separate geomatics division to facilitate the acquisition and utilization of such data.

4.1.6 National Security Advisory Council and Related Structures

The NSP also outlines the establishment of several new organizations to address the numerous national security requirements. Along with the appointment of a National Security Advisor, the NSP plans to establish a National Security Advisory Council made up of security experts external to government. This council could and should include membership from the space community. As well, it plans to establish an Integrated Threat Assessment Centre to centrally collect and disseminate threat-related information. Space based data and organizations associated with this function should be considered as an essential component of the Assessment Centre.

4.2 Other Main Players in Canada

4.2.1 Privy Council Office

The Privy Council Office (PCO) through its coordinating function and constant contact with other Federal Government Departments and agencies provides the Prime Minister of Canada its leadership and support for all aspects of government policy and activity. Within the PCO, there is the Deputy Secretary for Security and Intelligence, which has four primary roles.

- To support the Prime Minister by providing information, advice and recommendations on security and intelligence policy matters;
- To ensure the effective coordination among the members of the security and intelligence community;
- To be responsible, together with the Deputy Minister of National Defence, to the Minister of National Defence, for the Communications Security Establishment, (an agency which provides the government with foreign intelligence and guidance on the security of government telecommunications and electronic data processing); and
- To oversee the intelligence assessment function, a service based on interdepartmental contributions, which produces and coordinates intelligence assessments on a wide range of subjects for the Prime Minister, other Ministers and senior officials of government.

The work for the Deputy Secretary is supported by two secretariats, the Security and Intelligence Secretariat which provides overall coordination and policy direction and the Intelligence Assessment Secretariat, which provides foreign intelligence assessments and coordinates the interdepartmental assessment preparation.

4.2.2 Department of National Defence (DND)

The mission of the Department of National Defence and the Canadian Forces is to defend Canada, its interests and its values, while contributing to international peace and security.

Under Canadian defence policy, the Canadian Forces are called upon to fill three major roles:

- Protecting Canada;
- Defending North America in co-operation with the United States of America;

- Contributing to peace and international security.

Within these missions, DND may perform military operations, humanitarian relief efforts, search and rescue or support the Canadian public during times of crisis or disasters like the Ontario/Quebec ice storm or fighting forest fires. All military operations, whether domestic or foreign require a coordinated support structure which entails the collection, assessment and preparation of situational reporting that comprises of information obtained from many sources. Space based assets, whether Canadian owned or foreign owned make up an important component of this information.

Within DND, the Directorate of Space Development is responsible for Canada's military space program, and undertakes activities in conjunction with the CSA and other federal government departments, when a dual military-civilian use is identified. Space assets are also brought to bear in support of Canadian Forces overseas activities such as UN-sponsored peacekeeping missions. DND is also responsible for northern defence and for monitoring our coastlines in defence of Canadian sovereignty.

The Director General for Intelligence Capabilities is the responsible organization for collection, assessment and reporting. It provides through its Canadian Forces Joint Imagery Centre and the Mapping and Charting Agency, data from space based assets.

4.2.3 CSA

The CSA plays the lead role in the implementation of the Canadian Space Program, and many of the civilian applications also have a security aspect. Its objectives are to support and promote a highly competitive space industry and address the needs of Canadian society. The CSA works in close partnership with a large number of federal government departments and agencies.

The CSA's recent Space-based Earth Observation Strategy is founded on three pillars that are well-structured to highlight the use of space in support of security objectives: environment, resource & land use management and security & foreign policy. The third pillar is divided into three categories: situational awareness, support to foreign policy and disaster management.

Through and together with the CSA, the space community can plays a number of roles in relation to civil security activities and objectives in Canada. The roles can be considered in broad categories:

- Development of space technologies and applications to serve civil security objectives; this can be achieved directly, through cooperative in-house R&D, or more often in partnership, through programs such as EOADP and GRIP;
- Promoting and facilitating the use of space technologies and applications for specific uses, particularly through the promotion of government use of space for security in the context of GRIP;
- Provision of oversight and integration of security issues in global framework (whether regionally, nationally or internationally), through use of unique vantage point and EO, satcom and navigation technologies;
- Catalyzing the issue of space and security on the national agenda by promoting the development of a space and security policy at the highest levels of government and demonstrating to politicians and other federal departments how space can play a meaning role;
- Ensuring the existence and development of fundamental national space infrastructure (reception, testing, data archives, etc) to protect Canada's end-to-end space capabilities through the exercise of leadership amongst federal space partners (ICS members);
- Promoting industrial and commercial space activity in security related areas, particularly in geomatics industry, and international positioning of our industry in these growing markets;
- Strategic planning, to achieve and sustain the best advantages that space technologies, programs, products and services can provide for Canadians' economic, environmental and social objectives. Strategic planning is a process that helps to optimize consensus on objectives, to guide programs that develop and utilize space capabilities, to build vertical and horizontal relationships and partnerships, and to marshal sustained resources for implementation.

4.2.4 Natural Resources Canada and CCRS

Natural Resources Canada is the federal government department specializing in the sustainable development and use of natural resources, energy, minerals and metals, forests and earth sciences. The department deals with natural resource issues that are important to Canadians and looks at these issues from both a national and international perspective, using its expertise in science and technology, policy and programs. In addressing this mandate, Natural Resources Canada has long used space data and assets, particularly through the leadership roles played by the Canada Centre for Remote Sensing and the Canadian Forestry Service. It is also developing the GeoConnections Discovery Portal and the Canadian Geospatial Data Infrastructure to provide users with real-time access to remote sensing satellite and other spatial databases, both land and ocean, through the Internet.

Within the Earth Sciences Sector, the Canada Centre for Remote Sensing (CCRS), founded in 1972, is an internationally-recognized leading centre of excellence in the use of earth observation data, and supports an expanding industry sector including world leaders in global ground station, image analysis and radar mapping markets. CCRS is responsible for the reception, processing, archiving and dissemination of remotely sensed data for Canada. In conjunction with the private sector and academia, it develops remote sensing technology and applications. CCRS, through its National Atlas of Canada team, also works with industry to develop geospatial information applications.

4.2.5 DFO and the Coast Guard

Fisheries and Oceans Canada (DFO) is responsible for policies and programs in support of Canada's economic, ecological and scientific interests in oceans and inland waters, for the conservation and sustainable utilization of Canada's fisheries resources in marine and inland waters, for leading and facilitating federal policies and program on oceans, and for safe effective and environmentally sound marine services responsive to the needs of Canadians in a global economy and of using space data in support of both scientific research and operational mandates. Under the aegis of DFO, the Canadian Coast Guard uses space-based earth observation data produced by the CSA and by the Canadian Ice Service.[16]

The Canadian Coast Guard's mandate is to manage, maintain, and provide aids to navigation in Canadian waters in order to facilitate safe and expeditious movement of maritime traffic to protect the marine and freshwater environment, maintain maritime safety and to facilitate maritime commerce and ocean development. Helicopter and icebreaker patrols, coupled with video or satellite images, perform reconnaissance for the ice management/routing centre, which monitors an area extending from the Gulf of St. Lawrence to Montreal. It also makes use of the Differential Global Positioning system (DGPS), an extension of GPS that uses land based radio beacons to transmit position corrections to GPS receivers.

4.2.6 Department of Foreign Affairs and International Trade (DFAIT)

The Foreign Affairs component of the Department supports Canadians abroad, works towards a more peaceful and secure world, and promotes our culture and values internationally. Among the many initiatives, DFAIT maintains an active initiative in Global Peace and Security. This portion of their mandate is intended to maintain international peace and prevent violent conflict. It sets out to accomplish this goal through a range of initiatives, including collective security and defence arrangements such as NATO, NORAD and the Ballistic Missile Defence of North America. For many these aspects are essential to the security of Canada and North America, and as such contain a significant space component. As well, DFAIT is the lead government department on arms control and disarmament, a human security program and conflict prevention, human rights promotion and peace building activities. DFAIT plays a lead role with regard to data access control and technology proliferation controls, both serious concerns as civil and military space converge to address security issues.

[16] www.dfo-mpo.gc.ca

4.2.7 Communications Security Establishment (CSE)

The Communications Security Establishment (CSA) is mandated to carry out two prime functions; one, to acquire and provide the Government with foreign signals intelligence and secondly, provide guidance and services to help ensure the protection of Government of Canada electronic information and information infrastructures. The success of CSE in carrying out their mandate is very much dependent on their understanding of the telecommunications industry and the technologies that are used to support the industry.

4.2.8 Provincial and Municipal Emergency Planning Organizations

In many of the emergency planning contingencies, whether it is forest fires, floods, or even medical threats such as SARS, the primary delivery of emergency services comes from provincial or even municipal organizations. Their activities are often supported or augmented by nationally-based resources, including DND, and are increasingly using space-based data to improve the delivery of their emergency aid.

4.3 International Players

Canada participates in many international fora where security issues are a significant factor. In particular, Canada's involvement in international peacekeeping and humanitarian programs often deal with mass migration of people, natural disasters and other environmental security issues. The need for adequate, proper planning and subsequent deployment of Canadian resources requires information that is derived from space assets. As Canada does not have a domestic pool of resources to draw upon, Canada relies on accessibility to foreign data. Accessibility could be through financing the purchase of the data and imagery from commercial suppliers, or working in a cooperative manner with the international community, and receiving the necessary information in a "quid pro quo" arrangement.

One challenge for Canada is that there is no central agency or mechanism that could facilitate this process. With security issues now transcend many boundaries, such an organization could have numerous roles including consultation on the sources and selection of space-derived data, coordinate funding, or help in the interpretation of the data. Currently these roles are carried out by in-house (departmental) or lead agency expertise. Some departments have dedicated expertise such as National Defence or Natural Resources Canada, but often the expertise is departmental-function specific. As a result, other appropriate resources maybe missed, underutilized or inappropriately used.

Canada has historically relied on its close military relationship with the United States to have access to monitoring and sensing of sensitive areas, though more recently, the availability of RADARSAT data has on occasion provided a domestic source of information. The North American Aerospace Defense Command (NORAD) is the primary organization responsible for the protection of the North American air space. It is an integrated defense structure combining both Canadian and United States personal and assets. Space assets, albeit primarily military, are an essential component required for the collection of threat data and monitoring of the North American airspace.

Canada considers active participation in all NATO activities as an important role in maintaining international peace and security. The Department of National Defence and the Canadian Forces supply the main operational support for this activity. They therefore space-based information supplied by NATO allies and would also benefit from the ability to supply similar information in carrying out responsibilities within the NATO framework.

4.3.1 United States

The United States is the world's most advanced spacefaring nation, and has made more progress than any other nation in integrating space-based information into operational decision-making in the public sector. All US military organizations with operational responsibilities make use of both classified and commercial and civil assets. However, perhaps more significantly, a large number of US government organizations with broader security responsibilities are turning to space to address their needs. The Senate Governmental

Affairs Subcommittee on International Security, Proliferation and Federal Services recently requested the Congressional Research Service to conduct a survey of remote sensing data and technology use by federal non-military agencies. The benefits of satellite data and remote sensing to the defense and intelligence communities are well-known. The purpose of this study is to enable Congress to better understand how federal agencies use remote sensing and to understand the issues that arise in obtaining and applying the technology and data. The table below, which includes a number of security areas of concern, indicates the extent to which US civilian agencies have adopted remote sensing information in their mandates.[17]

Table 1. - Summary of Remote Sensing Data and Technology Use by US Federal Agencies

Data/Technology Use	Agencies(extensive)	Agencies (moderate)	total
Natural Resource Management/ Conservation/Environment	(7) USDA, FEMA, Commerce, Interior, State, USAID, EPA	(3) HHS, HUD, Transportation,	10
Monitor/study/quantify impacts from natural and man-made events/disasters	(5) EPA, FEMA, Interior, USAID, State	(2) Transportation, HHS	7
Basic & Applied Research	(6) NSF, USDA, EPA, Commerce, NASA, DOE	n/a	6
Mapping functions	(5) USDA, FEMA, Interior, USAID, State	(1) HUD	6
Early warning/mitigation of natural events and disasters	(5) USDA, FEMA, State, Interior, USAID	(1) HHS	6
Monitoring compliance/verification of laws, regulations, treaties	(5) USDA, Justice, Commerce, State, EPA	(1) Treasury	6
Agricultural use	(4) USDA, Interior, USAID, Justice	(1) HHS	5
Transportation/shipping	(2) Justice, Commerce	(1) Transportation	3
Conflict Resolution	State	n/a	1

The 20 agencies surveyed for this study span the roles of the federal government from basic research centers to law enforcement. All but four report some use of remote sensing data and technology in implementing their mandated missions. The remote sensing data application cited most often was for environmental and conservation purposes, with ten agencies reporting extensive or moderate use. Seven agencies reported extensive to moderate use of remote sensing for early warning, mitigation, monitoring, and studying the impact from natural disasters. Other uses include basic and applied research, mapping

[17] From "Assessment of Remote Sensing Data Use by Civilian Federal Agencies" dated December 10, 2001. Report by the US Governmental Affairs Subcommittee on International Security, Proliferation and Federal Services http://www.senate.gov/~gov_affairs/121001ispfsReport.htm This report provides a very useful summary of uses by US federal departments on a specific space based asset: remote sensing satellites. It touches upon many of the issues of security covered in this paper.

activities, monitoring and verifying compliance with laws and treaties, agricultural activities, and transportation and shipping.

The agencies reporting extensive to moderate use of remote sensing data acquire the data from a variety of government and commercial sources. The most common were governmental sources, such as NASA, NOAA, and USGS. Many agencies use non-U.S. sources, such as the European Space Agency and Canadian Space Agency, as well as commercial sources, such as LandSat5, IKONOS, and Orbview.

As our closest military ally, our greatest trading partner and our closest neighbor, we must work closely with the United States in matters of security. NAFTA is much more than a simple free trade agreement. Over 87% of Canada's exports go to the United States, while Canadian trade accounts for more than all European countries combined in the United States. The sheer volume of movement of goods and people, tied to historical ties and geographical proximity make close cooperation an imperative, despite difference of opinion with regard to threats and means to counter them. This will become increasingly challenging as the US pursues programs such as American National Missile Defence and seeks partnerships with Canada.

4.3.2 EU and ESA

Canada has strong military relationships with several EU nations, as well as being a founding member of NATO. Most military cooperation with Europe is undertaken in the NATO context. Increasingly however, security is being addressed in other fora adapted to the changing nature of threats. One major new initiative is the joint Global Monitoring for the Environment and Security (GMES) of the European Union and European Space Agency. As a Cooperating Member of ESA, Canada is a participant in both the GMES program and previously discussed Galileo programs.

GMES is designed to establish a European capacity for the provision and use of operational information for Global Monitoring of Environment and Security. In 2008 the foundations and the structuring elements of the European Capacity for Global Monitoring of Environment and Security should be in place and operating. This Capacity is seen to be composed of three modules, which together constitute the functional GMES "system":

1. the production and dissemination of information in support of EU policies for Environment and Security;
2. the mechanisms needed to ensure a permanent dialogue between all stakeholders and in particular between providers and users; and
3. the legal, financial, organisational and institutional frame to ensure the functioning of the system and its evolution.

The GMES capacity is geared towards the delivery of sustainable services supported by observation systems that may be in space, on the ground, in the air or sea-borne. Its potential and range could be significantly increased through combining with positioning systems and telecommunication satellites.

The implementation of GMES will include a structured dialogue with the users and the construction of a pan European partnership, associating owners and operators of existing or planned observation systems with adequate mechanisms for sharing data and information. In first instance, GMES is about bringing together existing and future users in need of environment and security data, such as environment departments, civil protection authorities. The GMES framework should serve to federate user requirements at a European level, to gather sufficient critical mass and to better use existing infrastructures and systems.

GMES has the potential to cover a wide range of policies. However, taking into account political priorities and the state of development of infrastructures, priority should be given to developing services in support of:

- **Land management** to support areas including agricultural policies, sustainable development of crops, early warning for food security, soil protection, management of natural resources, monitoring of bio-diversity, and urban planning.

- **Ocean monitoring** to improve understanding of climate change and to support the sustainable management of resources e.g. fisheries. **Maritime** transport requires adequate surveillance for increased safety and environmental protection.
- **Atmosphere monitoring** to contribute to understanding climate change, analysis of weather events and measurement of pollutants that damage human health. Services will provide real time information on atmospheric chemistry, pollution, aerosols and ozone components.

Risk management is required for natural and industrial hazards that threaten peoples' lives and cause significant damages to infrastructures. Services will include the provision of information on industrial hazards, floods, earthquakes, storms, forest fires, landslides and drought.

Humanitarian aid and security policies need tools for support, through the provision of mapping and decision support for aid and reconstruction, de-mining and development of tools for crisis management and conflict prevention.

These various services will require the use of specific Earth **observation systems,** in particular sensor technologies such as: high- and medium-resolution, optical and radar imagers for land surface, coastal zone and ocean monitoring; advanced optical and microwave sensors for atmospheric composition measurements and advanced active and passive microwave instruments for ocean monitoring.

Galileo is the other main component of the EU's activities in relation to security. Galileo will be Europe's own global navigation satellite system, providing a highly accurate, guaranteed global positioning service under civilian control. It aims to be interoperable with GPS and GLONASS, the two other global satellite navigation systems. By offering dual frequencies as standard, however, Galileo will deliver real-time positioning accuracy down to the meter range, which will make it suitable for applications where safety is crucial, such as running trains, guiding cars and landing aircraft.

4.3.3 Russia

Russia was the first nation in space with the launch of Sputnik in 1957, and the first nation to launch a man into space with Yuri Gagarin's 1961 mission. Even after the demise of the Soviet Union, Russia, and to a lesser extent the Ukraine, have continued to undertake significant space activities for security and other purposes. While Russia maintained an active EO capability for many years, which was used by the Russian federal government for security purposes, most notably to obtain information on domestic issues such as the war in Chechniya or other international concerns, the weak economy has curtailed Russia's ability to maintain an effective EO ability. In fact, at the moment, Russia does not possess a civilian EO satellite in orbit. Russian does have an exhaustive global catalogue of EO data which is of great use in background mapping sites around the world at relatively high resolutions. Russian industry maintains a solid EO capability and will likely continue to be a player in the future.

Financial difficulties have plagued many aspects of the Russian space infrastructure limiting the capabilities of numerous systems. The Russian equivalent of GPS, Glonass, is now only partially operational, precluding its use for many security applications and limiting the ability of Canada to work more closely with Russia, in addition to other security concerns remaining from the Cold War era. Russia has engaged in discussions with the EU about Galileo partnerships, but these discussions have not led to any concrete pooling of resources, and seem at loggerheads with parallel discussions the EU has had with China.

Russia remains a significant player in space infrastructure (launches and satellite construction), and the recent relative recovery of the Russia economy through the rise in petroleum and commodities prices offers some hope for the continuity of the space program. Russia is a partner with Canada in the Circumpolar Council, and though once a Cold War rival, may now be viewed as a potential ally in fighting new threats to security, whether natural disasters or man-induced problems.

4.3.4 China

China regularly uses space monitoring for surveillance purposes, and maintains a number of communications satellites for domestic needs. China's rapid ascent in the space technology field has produced many notable changes over the recent years. For example, their EO activities collecting high-resolution pictures that were formerly stored on film and returned via recoverable capsule now encompasses both civil and military electro-optical satellites that transmit image data to ground stations via high data rate radio links.

China maintains a RADARSAT-1 data reception station outside of Beijing and uses RADARSAT data for a wide array of applications dealing with resources and the environment. China co-chairs with Canada and France the United Nations Action Team on Disaster Management established during UNISPACE III.

Recent tensions with the United States over several issues, including but not limited to the potential sovereignty of Taiwan make security related relations with China volatile. While China continues to look for new space related technology, the Canadian Department of Foreign Affairs, along with its allies, continues to deny export licenses to Canadian companies seeking to sell satellite equipment that may have dual-use or military applications.

4.3.5 India

India has a major space program implemented through ISRO. India has for many years pursued a policy of national autonomy in space, which has led to the development of polar and geo-synchronous launch vehicles, robust communications satellites and the largest constellations of civil remote sensing satellites in the world. India has pioneered the use of space for development, particularly crop monitoring, and the use of space for disaster warning.

4.3.6 Brazil

Through the Brazilian Space Agency (AEB) and the National Institute of Space Research (INPE), Brazil has been developing a domestic space program which would comprise of both the construction of satellites and the launching of space vehicles, While it has made numerous advances and has collaborated with other countries such as the United States and China on producing EO satellites, in particular for environmental monitoring, Brazil has yet to make the anticipated dramatic step into launch vehicles. The space program is still recovering from a third major launch failure in August of 2003.

4.4 International Organisations

A growing number of international organizations are using space applications for the delivery of their mandates, particularly in relation to disasters and to refugee relief. The lead organizations in this respect on a declassified basis appear to be the FAO, the World Bank and the UNHCR, though military organizations such as NATO or the WEU regularly use space assets for classified purposes.

Depending on the sectors considered to be priorities by Canada, selecting a key international organization and working closely with them may be instrumental to achieving broad global recognition for the use of space for security applications in a given area.

5. Canadian Strengths, Weaknesses, Opportunities and Threats

In order to examine the potential opportunities for increased use of space assets in support of security related objectives, a SWOT analysis was undertaken. This allows us to identify where our key strengths lie, what weaknesses should be addressed and what opportunities are presented to us to move forward.

5.1 Strengths

- Recent definition of a clear Canadian National Security Policy;
- Canada enjoys a strong, special security relationship with the United States (particularly DoD);
- Canada has a long history of space activity;
- Canada has operational satellite capabilities in satcom and EO (Anik F2, RADARSAT-1 and soon RADARSAT-2);
- Canada has developed a world-class end-to-end EO space program capability;
- Canada has a world-class radar capability for space-based remote sensing;
- Canada has an established operational space radar expertise for near-real time applications (Ice Service);
- Canada has a user focused EO and satcom program;
- Canada has an emerging smallsat capability;
- Canada was a leader in the establishment of the Disaster Charter operational guidelines;
- Canada made early investments in European initiatives (ESA membership, Galileo, GMES);
- Canada has a strong university-based space research community (R&D);
- Canada has developed world-class climate research capabilities.

5.2 Weaknesses

- Canada lacks a clear, unified *space* and security policy;
- Space has a low profile in the Canadian security debate;
- Many Canadians mistake space and security as missile defence; space and security is a much broader issue, encompassing missile defence but including many other distinct and different issues;
- Canada has limited space funds and consequently few space assets; space investment is costly; Canada is spread too thin in space;
- Canadian security needs are great: we are a large, undefended, sparsely-populated country, sharing an undefended border with the global superpower (making us a target for their enemies);
- Canada is heavily dependent on foreign assets for defence needs and rarely has a stand-alone operational capability in security areas;
- Canada has no independent launch capability;
- Inability of key players in security area to co-invest at significant levels for space projects;
- Responsibility for security is distributed across federal and provincial jurisdictions.

5.3 Opportunities

- Renewed interest in security post September 11th and more recently in Canada through the National Security Policy;
- GMES highlights linkages between space infrastructure and policy and decision making at highest levels (potential partnerships and awareness spin-offs);
- Group on Earth Observations (GEO) Earth Observation Summit provides global context for planning new civil space missions;
- Space programs can offer operational savings for large scale surveillance activities;
- Space technology niche roles offer Canada barter and partnering opportunities;

- Reduced cost of space access and innovative technologies (smallsats, microsats) offer Canada a new end-to-end role in areas previously thought to be out of reach;

5.4 Threats

- US non-foreign reliance policy weakens perceived value of US partnership;
- US/EU tensions (we are caught in the middle);
- Strong US pressures on missile defence;
- Dependence on foreign space systems and space-based information to meet Canadian needs;
- High infrastructure cost of space programs;
- Perceived cost of increased security may become unpopular;
- Failure to recognize and react to myriad impacts of climate change.

6. Conclusion and Issues

Global economic growth and development is already dependent on reliable space-based communications, GPS and numerous remote sensing satellites and the dependence will increase as continued and improved applications for resource planning, agricultural development, transportation and urban planning, are developed and brought into operational use.

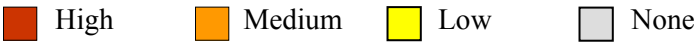
6.1 Overall Conclusion

In summary, the overall conclusion is that there exists tremendous potential to increase the role of space assets in security-related areas, both in the near and medium term. The table below summarizes the areas in which security applications make use of space-derived information and the potential for future use. While the table is only a subjective assessment of the authors, its anecdotal conclusion points to strong promise for future security applications in the space information sector in Canada.

Table: Canadian Use of Security Applications Based on Space-derived Information

Security Application	Use of Space-derived Information in Canada	Potential Use of Space-derived Information in Canada
Sovereignty		
Mapping and Cartography		
Wide Area Surveillance		
Coastal and Border Issues		
Environmental Security		
Environmental Monitoring and Change Detection		
Wildlife and Natural Habitat Monitoring		
Sustainable Resource Management		
Personal and Societal Security		
Health and Education		
Transportation and Border Security		
Policing and Enforcement		
Disaster Management		
Preparation and Early Warning		
Mitigation and Relief		
Damage Assessment		
Multilateral Treaty Enforcement		
Environmental Treaties		
Disarmament and Non-proliferation		
International Relief Efforts		
Situational Awareness		
Operational Support		

Foreign Policy		
Operational Support for Direct Action		
Monitoring in Support of Policy Objectives		
Threat Assessment		
Direct Assessment and Intelligence		
Collaborative Assessment and Intelligence Niches		
International Collaborative Scientific Research		
Climate Change Research		
Solar-Terrestrial Research		
Asteroids and other Earth-crossing Objects		



However, critical issues must be addressed in order to properly pursue the growth of security applications in the space sector. The principle issues are insufficient integration of space in security systems, the lack of space awareness in the security community, Canada's strong dependence on foreign assets, and the new vulnerabilities created by the lack of comprehensive, coordinated space systems.

6.2 Insufficient Integration and Coordination of Security Systems

The announcement of the NSP in early 2004, and the creation of a non-military counterpart to the US Department of Homeland Security, creates a formidable opportunity for the CSA to position space in the emerging organizational and policy structure as a critical tool for Canadian security efforts. A critical component of the use of space for security purposes both military and non-military in the US, the EU and most of the world is the strong political linkage between space and security. Most countries acknowledge that space has a critical role to play in security issues, and that security issues are paramount. In Canada, perhaps due close relationships with the US as an ally and nearest neighbour, little attention has been paid in recent years to security policy, and consequently the role space may play in relation to it.

A major thrust of the NSP is increased integration and co-location of capabilities. The CSA can capitalize on this by demonstrating that space plays a major role in support of domestic security objectives, and that the issue is completely independent of and largely unrelated to the issue of space militarization, with which it is often mistaken. In particular, space capabilities need to be made available to the Integrated Threat Assessment Center and co-located emergency operations centres (both federal and provincial). "Integrated" capabilities that do not include space assets and products will not be "integrated" and will place Canada at a significant international disadvantage as other nations pursue integrated, indigenous space capabilities with determination.

6.3 Lack of Space Awareness in Security Debate

While space enjoys a strong reputation in military circles and is generally recognized as being of strategic value, space information in non-military security circles is not as widely understood and respected. Part of this is due to problems inherent in the type of unclassified space information available for use in real time situations such as disaster management, which does not currently meet all requirements of disaster managers. Much is however due to insufficient information and examples on what can be achieved today with existing satellite tools. Yet another aspect of the problem is an insufficient understanding if the needs of user communities amongst information product developers or those setting priorities for product

development. Yet another problem in military circles is a lack of personnel to take advantage of space data and exploit its potential. This may be caused by a lack of awareness of the critical role space can play at the highest levels. The general lack of awareness of space as a strategic security "tool" must be addressed to ensure space can be brought to bear in security-related applications.

6.4 Dependence and Partnership

Canada is dependent on foreign countries for access to space. The decision not to develop a domestic launch capability was taken years ago, and is not likely to change in the foreseeable future for large satellites. With the emergence of new technologies however, small and even micro-satellites with impressive capabilities are being designed and built, and Canada may one day choose to develop its own capability to launch such small and inexpensive satellites into orbit. There are several private sector groups working on launch capability in Canada today that may pursue this route. In the meantime, Canada will continue to partner with many nations to ensure space access.

While working with several partners affords us some protection from denial of space access, it can also be a liability of not exercised with caution. The EU in particular has taken a strong independent path with regard to the US, and Canada is to some extent caught between both space powers. With the EU designing and building their own navigation system, to which India and China have joined, the US will look closely to Canada's positions on a wide array of space-related issues. On those judged most critical to US interests, Canada must decide where it stands. On purely military issues, Canada's closest ally is the United States, and joint capability is developed through this partnership.

Dependence with regard to launchers and navigation systems are likely to remain for the foreseeable future. More significant is Canada's dependence on EO and communications of allies when significant domestic capabilities exist. The technology landscape is changing as technology development accelerates. New capabilities offer Canada new opportunities to exploit in relation to security. Canada must review its partnerships in each technology sector and decide where to invest. If Canada is determined to maintain strong ties on both sides of the Atlantic, perhaps Canada needs to choose an EO partner on one side, and a commercial communications partner on the other. Whatever Canada chooses, not choosing is not a viable option.

6.5 Vulnerabilities and Gaps

A final critical issue raised by the use of space assets for security applications are the new vulnerabilities created by space reliance and the lack of comprehensive, coordinated systems to address user needs. It is difficult for users of security applications to accept dependence on assets that are not reliable, which are indeed prone to failure, costly to replace and often not conceived as durable, continuous systems. In order to address these concerns, the CSA needs to identify the sectors in Canada likely to be interested in developing space applications, the satellites they use and alternative sources of data for the prime data source. In parallel, while comprehensive systems are not available today, the CSA should begin charting paths to show how data continuity in critical areas (Landsat, medium resolution spectrometry, C-band SAR) is expected to be offered to users. If the CSA is not prepared to believe and invest in data continuity, there is little chance the user community will, and space applications, even in the security area, will remain the domain of scientific and academic demonstration for the foreseeable future.

7. Recommendations

In considering the vision for future space programs, the CSA should first address the needs identified in this report, and the issues that flow from them.

As a first step and significant priority, the CSA should seek the establishment of a National *Space* Security Policy, and seek to support the government in its NSP by:

- Coordinating space policy development with PCO, DND, DFAIT, PSEPC, EC, DFO and NRCan as key players;
- Demonstrating relevance to security objectives;
- Increasing awareness of space at the highest levels of government, particularly in security circles (e.g. National Security Advisor to Prime Minister); and
- Reaching out to security players beyond DND and forging new relationships.

In particular, new programs should:

- Position themselves within Canada's emerging security policy;
- Focus on identified areas of Canadian strength and be complementary to the programs of our partners;
- Seek partnership amongst our closest allies in each technological sector.

In a substantive sense, areas that are particularly promising for future Canadian space security systems include:

- Space-based SAR constellations for wide area, high revisit surveillance of Canada and the world;
- Integrated disaster management ground services and products;
- Integrated space and terrestrial communications solutions for North of 65°.

Canada should also make considerable investments in applications relevant to national security based on foreign sources of readily available data.

Targeted investments that exploit emerging technologies and offer Canadian users real capability will offer Canada greater international visibility and serve as useful, complementary information sources to allies and multilateral organizations pursuing common security goals with Canada.

Annex – 1: Acronyms

ADEOS-II	Advanced Earth Observing Satellite II
AEB	Brazilian Space Agency
CBSA	Canada Border and Security Agency
CBRN	Chemical, Biological, Radiological, Nuclear
CCRS	Canada Centre for Remote Sensing
CIDA	Canadian International Development Agency
CIPEP	Critical Infrastructure Protection and Emergency Preparedness
CNES	Centre National d'Etudes Spatiales (France)
CRYSYS	Cryosphere System in Canada
CSA	Canadian Space Agency
CSE	Communications Security Establishment
CSIS	Canadian Security Intelligence Service
CSP	Canadian Space Program
DFAIT	Department of Foreign Affairs and International Trade
DFO	Fisheries and Oceans Canada
DGPS	Differential Global Positioning system
DND	Department of National Defence
DoD	Department of Defence (US)
DOE	Department of Energy (US)
DRDC	Defence Research and Development Canada
EC	Environment Canada
EO	Earth Observation
EOS	Earth Observation Summit
EOADP	Earth Observation Applications Development Program
EPA	Environmental Protection Agency (US)
ESA	European Space Agency
EU	European Union
FAO	Food and Agriculture Organization (UN)
FEMA	Federal Emergency Management Agency (US)
GCOS	Global Climate Observing System
GEO	Group on Earth Observations (Earth Observation Summit)
GIS	Geographic Information System
GLONASS	Global Navigation Satellite System
GMES	Global Monitoring for Environment and Security
GPS	Global Positioning System
GRIP	Government Related Initiatives Program
GTOS	Global Terrestrial Observing System
HHS	United States Department of Health and Human Services
HUD	US Department of Housing and Urban Development
IAEA	International Atomic Energy Agency
ICS	Interdepartmental Committee on Space
IGOS-P	Integrated Observing Strategy Partnership
INPE	National Institute of Space Research
I-STOP	Integrated Satellite Targeting of Polluters
MDIS	Multispectral Digital Imaging System
MERIS	Medium Resolution Imaging Spectrometer (Envisat sensor)
MODIS	Moderate Resolution Imaging Spectroradiometer (US)
MOPITT	Measurements of Pollution in the Troposphere

NAFTA	North American Free Trade Agreement
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NGO	Non-Governmental Organization
NOAA	National Oceanographic and Atmospheric Administration (US)
NORAD	North American Aerospace Defense Command
NRCan	Natural Resources Canada
NSF	National Science Foundation
NSP	National Security Policy
PCO	Privy Council Office
PSEPC	Public Safety and Emergency Preparedness Canada
R&D	Research & Development
RCMP	Royal Canadian Mounted Police
SAR	Synthetic Aperture Radar
SARS	Severe Acute Respiratory Syndrome
SWOT	Strengths, Weaknesses, Opportunities, Threats
UN	United Nations
UNCLOS	United Nations Convention of the Law of the Sea
UNHCR	United Nations High Commission for Refugees
UNISPACE III	Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space
US	United States of America
USAF	US Air Force
USAID	US Agency for International Development
USDA	US Department of Agriculture
USGS	US Geological Survey
WEU	West European Union

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