Securing the Earth:
Contested Discourses of an
Earth Observation Industry

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© January, 2005

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ISBN: 0-494-00724-9

Our file Notre référence

ISBN: 0-494-00724-9

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Abstract

Earth observation technology is providing the means for humanity to envision and study the Earth as a single ecological system. This technology has also been used by states to project power and to secure access to strategic resources. A private-sector has now emerged in the United States and Canada that seeks to establish a global marketplace for satellite remote sensing imagery. The history, official policies and marketing strategies that define the activities of this industry indicate that discourses on sovereignty and security are important determinants to the trajectory that a commercial space industry will follow. This research suggests that an innovative and holistic regulatory framework is needed to balance private and public interests in space-based Earth observation and to ensure that the potential for this technology to inform on global ecological processes is realized for the common good.

Résumé

Les technologies d'observation de la terre offrent à l'humanité les moyens voir la planète et de l'étudier comme un écosystème unique. Ces technologies ont également été employées par certains états dans le but de prévoir leurs forces futures et de s'assurer l'accès à diverses ressources stratégiques. Un secteur privé émergeant dans ce domaine aux Etats-Unis et au Canada cherche d'ailleurs à jeter les bases d'un marché global d'images satellitaires commandées à distance. L'histoire, les politiques officielles ainsi que les stratégies commerciales qui définissent les différents volets de cette nouvelle industrie indiquent que les discours sur la souveraineté et sur la sécurité sont des éléments déterminants dans la définition de la trajectoire que prendra le commerce industrie de l'espace. La présente recherche suggère la nécessité de la création d'un cadre réglementaire innovateur et holistique afin de balancer les intérêts publics et privés en ce qui a trait à l'observation de la terre depuis l'espace et pour s'assurer que le potentiel de ces technologies à fournir des informations sur les processus écologiques globaux soit utilisé pour le bien commun.

Acknowledgements / Dedications

The work presented in this thesis could not have been possible without the guidance and support of many people. I would like to thank my supervisor, Dr. Fraser Taylor, for first giving me the opportunity to pursue this work and then directing my efforts to complete it, largely from afar. He was an invaluable source of support and guidance throughout my graduate program. For financial support and the opportunity to engage in policy discussions regarding the military uses of outer space, I thank Dr. Jennifer Simons, the Simons Foundation, and Dr. Robert Lawson of Foreign Affairs Canada.

I would also like to thank Doug King and Simon Dalby for further opening up the wide field of geographical enquiry to me – from remote sensing to environmental geopolitics. Kevin O'Neill from RSI graciously offered his time and expertise to answer my various questions concerning Radarsat applications. I also owe a debt of gratitude to my former supervisors and colleagues at the CNSC for allowing me to occasionally step out of my professional duties to engage in academic pursuits, for which they provided unwavering support and encouragement.

My family and friends have continually provided the opportunity for adventures such as this one now completed, and the conversational space to critically reflect on society's latest trends. Colin & Jen in particular provided a warm welcome during each of my visits. Foremost in my mind however is my mother Barbara who, as a geographer herself, inspired a passion for maps, language, culture and travel, and more than anything else, a deep appreciation for natural landscapes. My father Barry has also truly defined the term 'commitment' whether to a cause, a belief, or a person and it is this most important example that allowed me to 'stick with it' and persevere during difficult times.

Lastly, but so important to the completion of my 'first book' and a constant companion on this exciting voyage has been Sabrina, whose encouragement, patience, kindness and interest has enabled me to explore, express and share my thoughts and sometimes rambling dreams.

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1.0 INTRODUCTION

A new reality facing humanity is that we need to think on a planetary scale about our environmental impacts. From revelations over the past several decades about stratospheric ozone depletion, global warming, biodiversity loss and the effects of persistent toxic pollutants among others, it is becoming clear that human activities must be managed in accord with the kind of planet we wish to secure for the future. As Crutzen (2002) has described, a daunting task lies ahead for science and engineering to guide society towards sustainable management of the environment, suggesting that “this will require appropriate human behaviour at all scales, and may well involve internationally accepted, large-scale geo-engineering projects.”¹

One large-scale project of humanity during the past half-century has been the development of outer space and the placement into orbit of an increasing number of Earth observation (EO) satellites that, through remote sensing of the Earth’s environment, variously promise to deliver the strategic information required for its stewardship. EO satellites and remote sensing technology also acts as an ultimate enabler for groups wishing to identify and access new resources to secure economic outcomes. Between these two potentially divergent roles for the technology and geography of outer space, a private industry is emerging that seeks to capitalize on the perceived value of observing Earth from space. One certainty is that outer space is becoming an important geo-strategic arena, with technologies such as satellite remote sensing offering valuable data for environmental governance, a holistic frame of reference for sustainable development planning,

¹ Crutzen, Paul J. (2002) *Geology of Mankind*. Nature Vol.415, 3 Jan. 2002 p.23

and a means for powerful groups to pursue economic, political or state interests on a planetary scale. Human fascination with outer space, its technologies and their widespread utility has enabled outer space its products to be understood as resources of the global commons. But this rendering has also left these technologies prone to over-exploitation and under-regulation.

The early realization of satellites as ‘dual-use’ technologies has provided society with various ‘public good’ aspects of the technology such as weather forecasting services, civilian mapping and navigation, and monitoring of the environment. Satellite technologies have also long been used by military agencies tasked with gathering intelligence about adversaries or for asserting control over territory. The state of today’s EO technology coupled with accurate satellite-based geo-positioning information allows modern war-fighters to select and destroy targets from remote locations. The result is a potential theatre for war which has no specific territorial bounds.

Increasingly blurred by military use of space technologies are any conceptual lines that separate the use of this technology between civilian and military activities. As the space technology sector moves from its state-controlled origins into a global commercial marketplace, it is timely to examine how official policies, public needs and private sector activities will interact, shape and be shaped by modern discourses of *environment*, *development* and *security*. The use of each of these contested terms in policies and commercial activities governing the private-sector Earth observation industry will be scrutinized in the following research.

To support new thinking about global issues at appropriate scales, it has been suggested that new modes of dialogue and a rethinking of environment, politics and security are required for which a concentration of research has emerged that focuses on the links between technology, globalization, environmentalism and the shifting nature of sovereignty in international affairs (Litfin 1998;

Deudney et al. 1999; Matthew 2000, 2002; Dalby 2002, 2004). As one of the resultant effects of the Internet, global telecommunications infrastructure and the reliance of both these conduits upon visual information, new modes of dialogue within the media, epistemic scientific and academic communities or a global civil society may emerge (Kaldor, 2003). With an inherent global perspective, satellite technologies are often regarded as valuable decision-support tools for addressing issues which transcend geographical, political or ideological boundaries, contributing importantly to global transparency, described by Florini et al. (1999) as “the ineluctable wave of the future.”² In this regard, how space technology is developed, controlled, accessed and applied may have profound importance to the kinds of behaviour and global thinking made possible to address challenges including environmental change, ecological degradation and inequitable, unsustainable human development.

While there is a widely accepted notion within business and scientific communities, governments and the public that Earth-orbiting satellites are an indispensable tool for modern communication, commerce, and monitoring, there is less awareness of the role that satellite-based observation of the Earth can play in influencing strategic thinking about environment, development and security issues. While societal discourses, government policies and free market capitalism may influence the use of technologies such as satellite remote sensing, the use of geographical concepts and control of the information provided by this technology may in turn create ways of “seeing” the world, limiting available discourses, shaping strategic thinking and influencing policy choices and priorities for satellite operators.

² Florini et al. (1999), p.3

1.1 Problem Identification

Earth orbiting satellites represent a unique and powerful set of technologies that rely upon the use and exploitation of commonly shared geographic spaces. The targets of their observation are the Earth's atmosphere, terrestrial and aquatic ecosystems, and the human activities that take place in and influence the quality of these shared environments. The use of the geospatial information obtained by such satellites is pervasive in modern society and is global in scope. For these reasons alone, the rise of a commercial EO industry and a private sector that seeks to profit from the collection, development, control and dissemination of geospatial information should be of concern to society as a whole and is of specific interest in the field of geographic enquiry – both in the physical and human disciplinary branches.

Truly global access to geospatial information such as satellite imagery may support notions of the interconnectedness of human activities and environmental processes, furthering the ideal of global transparency that seeks to equally distribute the common good aspects of EO. But this will also require the technology of remote sensing to bridge gaps in the information and resource economies and provide useful tools to support international agreements that attempt to govern the global environment in a sustainable way. With commercial and private ventures in EO technology subject to control by state-based policies within certain international norms, the direction these policies and norms take will become a fundamentally important factor in answering the primary question being posed: how does commercialization and privatization in the Earth observation industry affect the application of this technology to global governance of the environment and to sustainable development decision-making? This question will be addressed by analysing the cognitive aspects and spatial concepts involved in EO, examining the historical

development, impact and uses of EO technologies, and by assessing official policies, commercialization plans and marketing information that support the activities of several private remote sensing satellite operators in Canada and the United States.

It is understood that the pursuit of private interests in EO may not prioritize the ‘public good’ aspects of the technology without strong accountability structures traditionally held in place by civil governments. In light of the international norm that recognizes outer space as a global commons, and the precedents established by other sectors of the Earth satellite industry (navigation, weather monitoring, telecommunications), this research will address the kinds of accountability or regulatory measures that may be required to ensure that private and commercial interests in remote sensing are balanced with common public interests.

As a prime stakeholder in the advancement of the science and policy interactions governing EO technologies, and as regular users of geospatial information resulting from EO, geographers have a unique interest in what trajectory this industry will follow in terms of issues of access and control as well as the affordability and interoperability of the data being collected. The field of Human Geography also takes a specific interest in the political economy of industries such as satellite remote sensing as it provides for an understanding of how information and knowledge about the Earth can be used to pursue certain political or economic interests. The industry also relies largely on a global economy both in scope and in scale, having significant potential to effect how human societies interact with and influence their environment in the future.

The problem being investigated in this dissertation essentially follows from a question asked over 40 years ago by a scholar of International Relations, Klaus Knorr: “How much will advancing space technology and development affect the intentions and/or capabilities of actors in the [world]

system, and hence, perhaps, also the operation of the system itself?”³ International Relations theorists interested in this field have argued that on balance, more positive than negative impacts to international society will emerge as barriers for countries to acquire their own EO satellites diminish.⁴ Theoretically, greater ‘global transparency’ could accompany the increasing availability and affordability of satellite imaging technologies to the government, the public, news media and non-governmental organisations (NGOs). It therefore follows that commercialization of this industry should be welcomed as a triumph of economic liberalization, free-enterprise and free-will over the previously wholly-owned government-controlled and military-dominated space sector. As Oliver Morton wrote in an article on satellite imagery in *Wired* magazine in 1997:

Like the telephone or the wrist watch, it is the sort of product that gets woven into the fabric of life – in this case, as an assumption that all the world is out there to be seen, that it is all available, comprehensible, and held in common... With shared eyes we will watch the world carry its cargo of civilization – its roads, its fields, its cities, its landfills – through time and space. This portrait will be an image that can zoom in to the personal and pull out to the geopolitical, a new way to look at borders, a new way to look at news. It will be an illustration of everything: not, in the end, a view from nowhere, but a view from everywhere, for everyone.⁵

The research that follows offers a cautious critique of this view however, arguing that a privatized, commercial satellite remote sensing industry may not provide the world with the panacea of a future democratized use of space-based observation technologies but may be more influenced by perceived economic opportunities and national policies that influence remote sensing development in support of sovereignty, nation-building and the *securing of the Earth* for territorial pursuits such as access and control of resources. In addition, the globalization of technological modernity inherent in the growing EO industry may serve to diminish important cultural and

³ Goldsen, J. (1963) pp.115-116

⁴ Dehqanzada et al. (2000) and Florini et al. in Baker et al. (2001)

⁵ Oliver Morton, “Private Spy”, *Wired* (Aug. 1997), p.9

political differences between groups while doing little to diminish existing inequalities between developed and developing regions of the world.

While some evidence may suggest that satellite monitoring can serve to reveal the constructed nature of political boundaries over bioregions therefore supporting new conceptualizations of *sovereignty*, there are also ethical issues about whose interests a private EO sector will serve. Indeed, a growing convergence of military, civilian and private needs in the remote sensing market poses serious questions about the relationships between these various actors and how the strategic domain of outer space will be developed in the future. An investigation of *security* discourses and their influence on commercial EO therefore becomes an integral part of this study as the contested meaning of security can be used to influence development of state and private-sector priorities for applying and controlling EO technologies. Beyond the texts of policies and corporate mission statements, discourses emerge through networks of media such as maps, the Internet, television and photography. How these discourses interface with society and the spaces we inhabit is a primary interest of this research as it applies to the commercial use of satellite imagery of the Earth.

As the global economy evolves ever more, extending its reach beyond terrestrial landscapes into the domain of outer space, it is becoming imperative for national economic and security policies to address the heavy reliance of governments and government institutions on information derived from and through outer space. As outer space represents to some the final frontier for human exploration, development and resource exploitation, policy agendas are beginning to reflect governments' heavy investment in and reliance on space technology, the information it provides, the knowledge it confers, and the power it projects.

Popular are claims that objective knowledge produced from satellite-derived data can assist in development, global governance of resources and the pursuit of environmental and human formulations of security in an open and transparent manner. The concept of global transparency and the objectivity of technology remain highly contested themes. The study that follows takes a cross-disciplinary examination of these issues, drawing from works in Human Geography and International Relations as well as sub-disciplines such as critical environmental politics, security and development discourse that are concerned with issues of control over information about resources and the environment, and on the competing views in technological society that both triumph and question human dominance over nature.

Perhaps one of the great epistemological challenges for modern society involves combining the competitive pursuit of the interests of distinct groups, public or private, with a need for cooperation towards facing wider societal problems. Adam Smith's theory of comparative advantage that is well integrated into the global economic system has suggested that the ever expanding pursuit of markets for profit will produce ongoing societal benefits. Therefore, the commercial exploitation of such important globally-shared geographies as outer space should effectively provide for the collective needs of society. However, competition for private property, ownership and control of resources contrasts greatly with the concept of sustainability. With a prescribed need for governments, corporations and individuals alike to constantly augment their positions of status (normally based in economic terms), it is possible that *sustainability* as a concept will remain an unrealized framework for moderating *development*. The global environment under Adam Smith's invisible hand hypothesis, may become the ultimate loser in society's ongoing competition to continually improve itself through technological advancement.

Certain technologies coupled with human innovation, ingenuity and adaptability however, do hold promise for supporting new thinking about global issues including the inter-relationships between society, the economy and the environment. While the proliferation of commercial remote sensing satellites may be yet one more set of technologies to be privately developed and controlled for the objectives of profit maximization, the widespread distribution of Earth imagery and geospatial data across cultures, borders and ideological boundaries could provide a context for the new forms of thinking that scholars suggest are required to address global problems.

The discourse emerging from governments such as the US and Canada through various policy statements, plans and priorities, supports the development of private firms within a commercial remote sensing industry, although significant differences in each country do provide a useful context for comparison. Can certain technologies and the policies that support their development balance the needs of the global community with so-called 'national interests' and how does market liberalization for certain technologies affect not only the trajectory of their development but the influence they have over humans and the environment? In the case of space technologies such as satellite remote sensing, their apparently silent and unassuming 'eyes in the sky' may actually prove to have direct influence in issues such as biosphere ethics, environmental governance, resource development, and the future accepted uses of outer space. When operated for profit by private firms, EO technologies may serve to secure the Earth for the interests of the few, or may reveal the path to a sustainable future for the wider global commons.

1.2 Document Structure

The following provides an overview of the basic document structure. Chapter 2 comprises a background and history section which will further define and describe EO technology, its emergence first as a tool for the military and then civil government, and the political, economic and societal issues relating to geospatial data production, dissemination and control. Chapter 3 provides a theoretical framework for this research undertaking. The body of theory within which this study is situated comprises international relations, political-economy, environmental politics and some philosophical reflections on space, visual theory and cognitive processes regarding the processing of geographic information. Drawing from this summary of existing research and theoretical endeavour, the methodology in Chapter 4 is followed. While predominantly theoretical in design, this study comprises both a documentary analysis of several policy documents and a qualitative and quantitative analysis of basic marketing documents and data to explore trends within the identified commercial remote sensing sector. Chapter 5 presents these qualitative and quantitative analyses commencing with a summary of historical trends in EO technology, international cooperation and policy development in Canada and the US and then proceeds with a comparison of various commercial EO ventures. Chapter 6 further develops the analysis presented in the previous section and discusses broader emergent themes within policy approaches, marketing strategies and competing discourses of environment and security. Chapter 7 formulates a series of recommendations and general considerations for governments, policy-makers and EO providers, highlighting strategies to promote environmental and sustainable development applications in the commercialization cycle of the EO industry. Chapter 8 concludes with a summary of primary findings.

2.0 BACKGROUND AND HISTORY

A growing amount of high resolution⁶ Earth imagery and geospatial data is available to those with the technological means, know-how and budget to gain access. A significant number of private companies have recently emerged to join the numerous civilian, government-run EO programs in the collection and processing of geographic data and satellite imagery. While the major actors in this industry are based in the developed world, there has been wide speculation that competition within the private EO industry will profoundly affect the availability, access and cost of imagery and data, enabling developing countries and smaller actors to gain greater access to geospatial information for various purposes including environmental governance and sustainable development.

2.1 Introduction

The geography of outer space represents an environment in transition. Influenced by a growing number of civilian, scientific, commercial, private and military actors, space is being transformed into a new political, economic and military centre of gravity.⁷ While the development of outer space represents the unprecedented technological advancement of human society over the past half-century and technologies such as communication, navigation and observation satellites hold great promise for improving human livelihoods, growing dependencies on these technologies and

⁶ Resolution is a measure of the smallest possible discernible distance between two adjacent objects using a specific sensor. For the purposes of this discussion, a high resolution image is considered a digital picture where the length and width of each pixel represents a ground distance of less than five meters. See M.R.B. Forshaw et al. "Spatial Resolution of Remotely Sensed Imagery: A Review Paper" *International Journal of Remote Sensing*, Vol.4, No.3 (1983), pp.497-520.

⁷ Lambeth (2003), p.99; and Department of Foreign Affairs - Canada (2004), p.4

the information they provide for a range of applications are continuing to pose serious questions about control, access and appropriateness of use.

Of the wide array of space technologies and applications developed since the 1940's, satellite-based remote sensing represents a suite of technology that is widely recognized as indispensable for international commerce, military applications and for obtaining and communicating data critical for understanding Earth systems and the human-induced impacts on these systems.

Broadly defined, EO by remote sensing is "the measurement or acquisition of information of some property of an object or phenomenon by a recording device that is not in physical or intimate contact with the object or phenomenon under study."⁸ While aircraft and satellites are both common platforms for remote sensing systems, the discussion that follows limits itself primarily to the consideration of space-based EO platforms, due to their unique ability to provide continuous global monitoring coverage that largely takes place on a scope and scale that is beyond the awareness of most Earth inhabitants.

There is a wide and ever growing spectrum of commercial applications for this technology that include in the broadest sense, satellite, launch facility and ground-station design and construction, the maintenance of supporting communication networks, software, hardware and expertise for managing and processing imagery, the sale of data itself and a very large variety of value-added products and services. A wide spectrum of specific applications for remote sensing has been extensively documented and discussed in the technical and scientific literature since this technology was first made available outside of military research programs in the early 1960's. While this dissertation concerns itself more with recent policy and societal issues relating to the commercialization of the technology and any impact this may have on environmental governance

⁸ Colwell (1997), p.33

and sustainability in development, many of these issues can be identified by placing current developments regarding this technology in their historical context. By summarizing some of the many uses this technology has been put to domestically and internationally through a historical review of remote sensing development in Canada and the US, the breadth and depth with which satellite remote sensing has been integrated into modern society since its emergence almost half a century ago can be seen. In addition, taking a historical approach can reveal important trends in political and economic decision-making respecting the development of space technology. Such trends include the establishment and furthering of societal values and priorities with respect to the peaceful uses of outer space, international collaboration, sovereignty concerns, and the application of space technologies for ‘common good’ purposes such as weather and environmental monitoring, global navigation and telecommunications.

2.2 Placing Earth Observation in its Historical Context

For millions of years, humanity has stared up at the stars and questioned our role and purpose in the universe. It is from nature that the ideas and scientific principles underlying artificial satellites came. Observations of the moon and other celestial bodies and perhaps an unwillingness to accept the realization that we may be alone as the only life-bearing planet in the solar system underlies the drive for humanity to leave the pull of Earth’s gravity and explore the universe.

Remote sensing satellites and their sensors – the technology under study in this dissertation – were themselves originally developed by state entities as a military enterprise. The term ‘remote sensing’ was first used by the military to describe aerial surveillance that went beyond the use of photography in the visible part of the electromagnetic spectrum to incorporate infrared and microwave parts.

Global political ideologies in the post World War II climate were divided into East and West. In the decade following, this geopolitical sphere began to expand to include not only land and sea, but airspace and outer space as well. Following on the heels of inter-continental ballistic missile (ICBM) development, Earth-orbiting satellites were born. If not at first tasked with strategic military purposes, airborne surveillance soon matured into the realm of space with the advent of satellite imagery.

After the successful launch of the Soviet Union's Sputnik-1 satellite on October 4, 1957, radio operators around the globe trained their ear to the signal transmitted back to Earth from the first orbiting human-made object. The event now seems quaint compared to the rapid evolution of space technology since 1957, but placing Sputnik into orbit is understood to represent the origin of the modern Space Age. Indeed, this event provided an early recognition that technological prowess in satellites and the capability to place them in orbit, held strong symbolic value for the enterprise of nation-building, in turn conferring much international influence and political power to space-faring nations.

The launch of Sputnik represented the height of scientific and technical progress in the middle half of the 20th century, but it represented even better propaganda, placing the development and acquisition of space technologies high on the agenda of many industrialized countries at the time. It was during this early period of international competition between the Soviet Union and the US that formative impressions for a US space policy came into being. Competition between these two states in ICBM development, the same technology that provided launch capability for their space programs, provided much of the sub-text for the fears that motivated space development. The Soviets had successfully tested an ICBM a few weeks before their first Sputnik launch, which

was described in the West as “a devastating blow to the prestige of the US as the leader of the scientific and technical world.”⁹ The Soviet satellite launch was seen as “one more proof of growing Communist superiority in the all-important missile field. If this now known superiority develops into supremacy, the position of the free world will be critical.”¹⁰

Co-incident to the very day of the Sputnik launch had been Canada’s own public roll-out of its Avro Arrow fighter jet, a project underway since 1952 that was considered one of the most sophisticated aerospace technologies at that time. The resulting effect of ICBM development and the dawning of the Space Age that suggested missiles would replace human-piloted aircraft caused Canada to rethink its approach to strategic defence. A decision to collaborate with the US on continental defence issues saw the signing of the North American Air Defence treaty (NORAD) signed in 1957. Two years later, the Canadian Government scrapped the Avro Arrow program to purchase Bomarc missiles from the US. In the ensuing years, the burgeoning Canadian aerospace industry lost of a considerable degree of its expertise to the US.¹¹

Military applications of space satellites were soon realized by both Superpowers, tasked with surveillance, intelligence gathering and for selecting militarily-actionable targets against opponents, all of which posed serious questions about sovereign space and the conduct of psychological warfare. It is clear that military applications dominated early space-based remote sensing efforts with the US Corona satellite program delivering its first film of the USSR on August 19, 1960.¹² To support analysis of the data from these systems, the National Photographic

⁹ Senator Henry Jackson, Democratic Chairman of the Military Applications Subcommittee on the Joint Committee on Atomic Energy, 1957 as quoted in Bulkeley (1991), p.5

¹⁰ Bulkeley (1991), p.5

¹¹ Don Harron’s CBC Morningside Broadcast (Feb. 20, 1979) available at <http://archives.cbc.ca>

¹² History of the National Geospatial-Intelligence Agency http://www.nga.mil/StaticFiles/OCR/nga_history.pdf [accessed Nov. 8, 04]

Interpretation Center was formed in the US combining Intelligence, Army, Navy, and Air Force assets. It was this group that first identified the Soviet plans for basing missiles in Cuba by exploiting images from U2 aircraft and film from canisters ejected by orbiting satellites.

While difficult to imagine the diverse range of imagery requirements for the military, it is now clear that detection of objects in the size range of 1.5 metres was technically feasible by the US military's Corona program in 1967 and possibly even several years earlier.¹³ While military space technologies have traditionally been far more advanced than those available for civilian use they have generally been geared towards object detection to assess foreign military capabilities and for operational support during conflicts.

The priorities of technologically advanced nations have arguably shifted in the post Cold War era from territorial concerns to ensuring their economic competitiveness in a global marketplace. As a result of ensuing military liberalization, the civilian and private-sectors have been provided access to military space technologies and have begun to compete in this sector. Today, civil and private EO satellite operators are providing imagery and applications that are complementary to the needs of defence and intelligence agencies. Military and intelligence agencies are now even becoming somewhat dependant upon commercial satellites to fulfill both their communication and imaging requirements.¹⁴

Satellite-based Earth remote sensing and surveillance technologies are becoming as integrated into technologically-advanced societies as are the related telecommunications and navigation technologies. Combined, satellite technologies are increasingly affecting political, economic and

¹³ Monmonier (2002), p.10

¹⁴ Agence France-Presse (April 1, 1998) "Military Depends on Civilian Satellites"; Space Daily (April 8, 2002) "Civilian Satellites Used to Help Plan Attacks in Afghanistan"; Globeandmail.com (March 28, 2003) "Pentagon Turns to Commercial Satellites to Ease Wartime Data Squeeze".

military decision-making, symbolizing a new sensory organ that we have created. Michel Foucault has argued that surveillance technologies have been the basis for the state's administrative power throughout the modern era, suggesting a strong role for technological superiority to play in international relations and economic competitiveness as well. As Martin Edmonds (1993) has described, "too large a dependency on foreign technologies may have serious long-term implications for the maintenance, development and ultimate international competitiveness of the nation,"¹⁵ a statement that may equally hold true for civilian and defence technologies in the global market economy. As the knowledge content largely provides the strategic value in high-technology products, international power status can be conferred on states that develop dominant information collection capacities.

In addition to the nation-building enterprise of space development, early efforts were also made to internationalize outer space. The member states of the United Nations recognised the potential for satellites to contribute to international peace and security, and proposals followed suggesting that arms control agreements could be verified from space, and even that an international agency could oversee and deploy satellites in the cause of peace. International organizations were established to disseminate global weather information derived by satellites, and other multilateral bodies gained responsibility for managing frequencies available for satellite communications. This early recognition of the international scope of space-development suggests that debates concerning public and private interests in EO are also applicable to the wider study of international affairs. Indeed, at the same time as the military implications of the space race were being felt, the potential for satellite technology to reveal information about the Earth and promote forms of international cooperation were being understood. Even during the launch of Sputnik, activities of

¹⁵ Edmonds (1993), pp. 45-64

the 1957 International Geophysical Year (IGY) were underway, bringing Earth-scientists from 70 nations across the globe together in the pursuit of technologies and policies that could promote greater international collaboration in understanding the Earth's environment.

Following the Sputnik crisis that heightened the East-West divide between social, political and military ideologies, civilian space programs emerged rapidly in the West, benefiting from some of the technologies being developed for the military. Using Werner Von Braun's successful launch vehicle design,¹⁶ the US placed Explorer-1 in orbit in 1958, formed the National Aeronautics and Space Administration (NASA) during that same year and rapidly urged democratic nations to join the US in cooperative space development enterprises. As a like-minded neighbouring state and an early pioneer of the development and application of aerial photography, photogrammetry and airborne geophysics due to its very large and remote territory, Canada became one of the earliest partners in the US program.

Building on a 1959 agreement signed with NASA that would see Canada design, construct and finance its first research satellite with launch facilities provided by NASA, Canada emerged as a prominent player in space development. In 1962, less than five years after the Soviet launch of Sputnik-1, Canada launched the Alouette-1 scientific satellite and became the third country in the world to establish a national presence in space.

In 1963, the Environmental Research Institute of Ann Arbor held an unclassified international symposium on remote sensing – the first of its kind as advanced remote sensing technology had previously been classified by the US Department of Defence due to its use in U2 reconnaissance flights, spy satellites and airborne infrared line-scanners used in Vietnam and other Cold War

¹⁶ A fascinating controversy exists in the role that Nazi German military rocket technologies and scientists played in forging the successful US ballistic missile and space programs following World War II

operations. With civilian groups able to broadly access the knowledge potential of remote sensing for space-based EO for the first time internationally, this symposium perhaps marks the historical debut of mainstream civilian remote sensing.

2.3 Space Technologies and their Ground-Effects

To demonstrate the importance and timeliness of a critique and analysis of the EO industry and the policies shaping it, several important broader considerations or ground-effects of the EO industry also need to be explored. Many academic studies within the social sciences have undertaken to examine related theoretical aspects, and a broad examination of this body of theory will help to construct the arguments and discussions that follow.

This study is complementary to a broader field of enquiry that is concerned with the societal and environmental impact of modern technologies, global economic processes and associated trends toward the privatization or commercial use of public spaces and goods. From a geographer's perspective, the advancement of EO as a commercial technology available to the world market increases the need to understand the importance and value of geographical concepts and geospatial information to decision-making on many levels. A study of this evolving sector will inevitably raise significant policy questions about how to balance the interests of private and public stakeholders in the use and development of industries that rely on the exploitation of commonly shared geographies such as outer space. Questions are also raised about the roles of national and international regimes to pursue policies that may inevitably shape the future use of outer space, or provide important knowledge about human and ecological conditions.

Scholars of Geography have been asking of geospatial technologies and their application, some of the same essential questions being asked of the information revolution in general but

distinguished by “the spatial twist.”¹⁷ Issues of concern include who has power over and access to technologies and information, aspects of democracy and political decision-making, as well as consumer sovereignty, privacy, social justice, equity, surveillance, control, gainers and losers, opportunity costs and the role of education and research. But unique to geographers and central to this study is the question of how society and environmental governance is affected by a growing diffusion of satellite imagery and related geospatial information. The issue becomes crucially important when information derived from such technologies is used to represent or understand a particular space in a particular way, conveyed to large groups of people who had limited knowledge of the forces of production that lay behind the representation. From military strategists using satellite imagery of supposed clandestine weapons facilities to development agencies calling for response to famine or natural disasters, errors of omission and commission and biases in classification algorithms that identify objects and prioritize geographic elements, all have an effect in the production of certain discourses and policy actions that can be as serious as war or as subtle as monitoring the day to day emissions of ground-level pollutants. The contested ‘securing’ of meanings about the Earth through the use of EO is therefore a primary theme running through much of the research that follows.

The near-Earth space environment provides an unrivalled panoramic viewpoint for Earth observation. Satellite technology and supporting software, ground station networks and communication infrastructures have now reached a level of sophistication that enables relatively constant whole-Earth observation across a wide range of the electromagnetic spectrum, at increasingly high spectral and temporal resolutions, and in spite of constraints such as atmospheric interference or cloud cover. Increasingly, this technology represents a backbone to

¹⁷ Couclelis (1999), p.20

the infrastructure supporting much of the Information Age and global economic processes in addition to the important understandings gained of global environmental change. From accurate weather forecasting to news and market analysis to strategic resource, environmental and military planning – the capabilities of satellite technology are increasingly available at some level to all societies, making its impact both more profound and accepted as just another indispensable product of the global economy.

Besides their use for scientific research and strategic planning, the direct use of images and information collected from outer space has become pervasive in such diverse applications as corporate logos, advertising and the promotion of environmental ideals. All kinds of businesses commonly rely on the visual power of Earth imagery to convey a message to consumers that the world's markets and remotest travel destinations can all be readily accessed and exploited at will. In contrast, Earth imagery is commonly used as a dramatic backdrop to convey notions that the Earth is a lonely fragile blue planet requiring careful stewardship, responsible management of resources and preservation of natural spaces.

While the symbolism of the planets and stars has long inspired human beings to think about their place and role in the universe, the increasing availability and pervasiveness of Earth imagery even in its simplest direct form is providing new opportunities for conceptually locating ourselves as integral actors in a complex ecological system and for understanding the interconnected nature of human activities and global environmental processes. This discourse, perhaps best described as an ethic of environmental attachment to the Earth, is in contrast to a second set of imaginings that arise from Earth images from space. The contrasting view is characterised by a realist perspective that calls for development beyond the confines of the Earth, while increasingly subjecting it to

scientific study, description, classification and to human control of territory and information either overtly or through the diffuse power of global commercial market forces. This second discourse could therefore be described as the process of environmental detachment. As Karen Litfin (1998) has described,

...by making visible the invisible, satellite imagery renders nature subject to claims of ownership and control. On the other hand, in light of the globality and transparency inherent in [Earth remote sensing] technologies and the emphasis on environmental cooperation, [Earth remote sensing] has the potential to become a tool in the revisioning of nature as a global commons.¹⁸

Visualization and cognitive processes related to satellite Earth imagery can therefore support two contrasting and perhaps conflicting views of the relationship between humans and the Earth: Nature as increasingly subject to control by observers, or communalized with responsibility shared among a growing number of stakeholders.

The two predominant discourses suggested above are represented in practice by two potentially conflicting trajectories within the growing commercial remote sensing industry in Canada, the US and elsewhere.¹⁹ On the one hand, civilian space programs have established a commercial remote sensing market based on the provision of tools, expertise and data for 'common good' purposes such as studies of global climate, biodiversity loss, ozone layer depletion, cross-border contaminant transport, and natural resource and disaster management. On the other hand, substantial commercial opportunities exist for EO in support of national sovereignty concerns including border monitoring, defence and resource exploitation. These two arguably distinct trajectories for EO application development may be largely influenced by the perceived

¹⁸ Litfin, K. (1998), p.196

¹⁹ France's Satellite Pour l'Observation de la Terre (SPOT) is also a major supplier of data to the commercial remote sensing market but is largely a state-owned and controlled enterprise. Many other space-faring countries support commercial remote sensing industries but the US and Canada are currently distinct in their pursuit of policies that directly support and promote private remote sensing industries and in the granting of exclusive distribution rights to private industry for remote sensing data.

importance of EO in pursuing each respective activity, and in the popular formulation of ‘security’ discourses that range from a state formulation concerned with national border protection to environmental and humanitarian formulations that focus on the needs of individuals.

Security is also a concept related to the future, or fears about future insecurities. What gives rise to the urgent direction of policy-makers is that which can most effectively be expressed as a threat. How threats and insecurities are therefore defined can become a primary element in the construction of perceptions of importance for EO technology development, application, ownership and control. If security is something that can be ‘achieved’ then it is something that can presumably be maintained, controlled, planned for and commodified. While the reformulation of national security into human and environmental security has been urged by significant academic and policy effort across various disciplines, even a very brief review of the prevailing decision-making powers of policy makers in each camp reveal that budgets and power are greater for those who control the narrative in the most compelling ways.

While government policy apparatuses are often slow and cumbersome, popular media is quick to respond to the images provided by EO satellites. An image of a recent bombing or terrorist attack has direct visual appeal compared to the more difficult visualization required to witness environmental threats emerging from climate change. The inherent neutrality of the technology of EO leaves its use and control susceptible to the most compelling discourse on security.

Military liberalization in the post Cold War era, a trend towards efficiency through transfer and use of commercial technologies wherever available, may have been influential in the development of private-sector EO technologies. Increasing budgets for intelligence agencies and ‘homeland security’ following the events of 9/11 may influence commercial EO applications development

particularly in the US. It is difficult to imagine a future when the private-sector could engage in the level of basic scientific research undertaken by civilian or defence space programs – indeed, as will be seen, this is not within the mandate of private-sector actors who see themselves primarily as providers of geospatial data and applications in response to the trends of the global market. It is also difficult to imagine a private-sector EO industry detached sufficiently from the budgetary cycles and policy influences of governments that it might pursue an independent trajectory in commercial development. When global market trends for EO are so heavily influenced by post-9/11 fears about national security formulated in a territorial sense, other discourses of global security that build on the information supplied by EO technologies might be obscured.

Research by Ronald Diebert (2003), Ann Florini and Yahya Dehqanzada (1999, 2000) and Karen Litfin (1998) has directly engaged with some potential global political ramifications of unfettered observation of the Earth from space, asking: “What are the consequences of increasing privatization and commercialization of Earth remote sensing activities?”²⁰ By examining the historical development of space technology and by observing the process by which EO has been integrated into the global economy, it could be argued that state competition in technology development for economic imperatives has outweighed the need to address environmental and societal problems. In addition, the state-controlled technology-driven economy of EO has been accompanied by contradictory policies that limit the globalization of valuable information products. For several decades civilian satellites have been observing and measuring human impacts on the environment from space, but much less has been actually achieved in addressing these impacts themselves.

²⁰ Diebert (2003) p.105 in Lambright (2003), Ch.3

While many space ventures have provided valuable evidence of global environmental problems and development concerns, justification for space science, exploration and particularly defence spending is increasingly being sought. In part due to the scale and magnitude of space technologies and the nationalist pride that often accompanies space exploration, modern society has been passively consuming the products of space technology including satellite imagery. The phenomena has been described as a process of seductive entrapment that traps progress towards problem-solving as significant public funds are channelled into state-run space programs in exchange for consumer products. According to cultural theorist Arthur Kroker: “One of the agitprop propaganda tactics of the military in the space program... is to say there’s this incredible spillover of civilian applications for military technology” while in reality military programs serve a very traditional anthropological function – to conduct war.

The development of outer space and its technologies have become publicly-supported priorities for many leading industrialized nations and a growing number of developing countries as well. How will a private EO industry, now an active player in outer space development, be accountable to the needs of the public? An increasing requirement exists for the enterprise of outer space development to be viewed through the lens of critical reflection, an effort for which the following pages are intended to modestly contribute.

3.0 THEORETICAL FRAMEWORK

3.1 Introduction

The investigation undertaken in this thesis is underpinned by several areas of theoretical endeavour, commensurate with the initial scale of the study to include space technologies and their societal effects, policy issues surrounding geospatial information such as public access to satellite imagery and the importance of discourse in promoting certain views and understandings of security, environmental issues, economic development and sustainability.

Satellites in orbit around the Earth that transmit data on global processes may appear to operate in a neutral fashion at an appropriate global scale to deal with the magnitude of emerging environmental problems.²¹ Earth observation (EO) technology indeed represents a powerful tool for the study, assessment and verification of conditions on the Earth, but the impact of the growing availability of this tool to a broad range of groups is not limited to issues of technological advancement. This dissertation builds on theoretical work in Human Geography and International Relations that sees the development of technologies such as satellite remote sensing as influenced by an array of geopolitical and social dimensions that have largely been overlooked in the technological field itself.

As Karen Litfin (1998) and others have argued, technologies, particularly exemplified by EO, are not neutral due the functional meaning that people assign to them. Perhaps less visible within the

²¹ Diebert, (1999) p.268

growing remote sensing community are issues of power, authority and control over the information collected by satellites that, given the range of applications of the technology, are crucial elements of both geopolitical and environmental decision-making at the state and international levels. If the global community is to rely on EO for environmental data and decision-making, an understanding of the technology that mediates the information flow must ensue.

Of common interest to geopolitical theorists is the manner in which new technologies are adapted to geographic imperatives, becoming a variable in the direct relationship between geography (in this case thinking about the environment), and politics (in this case concepts of security, economics and governance). By a broad examination of the following two themes and discourses surrounding commercial EO technologies, an understanding can be achieved as to how different expressions of role and purpose can support certain outcomes:

1. Information provided by Earth observation satellites is vital to the maintenance of national sovereignty, the securing of territory, resources and economic competitiveness;
2. Widespread access to Earth observation technologies can provide crucial information for global sustainable environmental governance and can democratize access to resources, securing a sustainable Earth for future generations.

To begin to understand the role that spatial technologies such as EO might play in affecting change over human-environment interactions, the processes by which geographic concepts and metaphors influence certain modalities of thinking need to be examined. A wide body of academic research (Harley, 1989; Taylor, 1991; Pickles 1995; Chrisman 1997; Couclelis 1999; Goodchild 1999) has focussed on the relationship between the development of spatial technologies such as geographic information systems (GIS) and the concepts predominant in

resource management, land-use planning, and environmental assessment, fields that make frequent use of GIS and geospatial data, increasingly including commercial satellite imagery. From this literature, strong inference can be made not only to the importance of the design characteristics of geospatial technologies in influencing how data is obtained, accessed and used, but also in discourses associated with the technology that can prejudice certain representations of the world over other alternatives.²²

While many applications of satellite imaging technologies have been studied and widely applied to both national sovereignty and ‘common good’ applications, much less study has been focussed on how remote sensing policies have affected the development, ownership and application of the technologies themselves. Increasingly being questioned in modern societies are relationships between the private and public sectors. Of specific interest in this regard is how the public and private development, ownership and application of geographic technologies can influence modes of thinking about the Earth in its social, cultural, political and economic representations. The paragraphs that follow will attempt to summarize aspects of the academic literature that relate to these issues, and establish where this research project is situated within the field of Human Geography and International Relations.

3.2 Technology and Relationship to Humanity and Nature

While many technical applications have been developed for remote sensing and satellite EO, making it an economically viable commercial industry within the global economy, scholarship has begun to scrutinize privately-controlled industries that survive off access to public goods and spaces. Increasingly, environmental and social scientists are concerned with the wholesale technological advancement of the industrialised world and the effect this might have on detaching

²² Taylor (1991), Pickles (1995)

humans and human activities from their surrounding environment, both physically and psychologically. An ever evolving technology-based global economy has arguably subjugated 'Nature' and livelihoods of sufficiency to the primary goals of capital accumulation and consumption. Despite new thinking about how to measure the individual quality of human livelihoods, common economic practice is to assess a country's ability to engage with the trends of an internationalized global economy and use this as a basis for measuring the 'success' and well-being of its individual citizens. This system touts the importance of pursuing the modern means of mass production, advancing technology, private property, free trade, global market competitiveness and capital accumulation and consumption all as measures of progress. The scale of this system of thinking operates at the international and state levels but has filtered down to individuals whose success and well-being becomes a measure of both their level of consumption and their ability to consume, commensurate with the productivity of the state as a whole. While the integration of modern technologies into society offers new efficient means of production and resource exploitation, it also increases the widespread societal trend toward the mass consumption of resources.

When attempting to address 'environmental problems' at the global scale through the widespread application of science and technology, it is critical to first understand what is meant by 'environment' and get a sense of the role science, technology and associated terminology can play in a de-facto separation of humans from the biogeochemical processes that our lives interact with. Recognizing the contested nature of the word 'environment' is a first step to understanding why 'environmental governance' is a difficult concept and why technologies themselves can become part of a problematic discourse. As 'environment' can be understood in empirical, analytic terms as the totality of biogeochemical reactions on Earth (Slaymaker, 2004) it is clear that technology

and science will be geared at all scales to offer potential solutions to problems. When technologies such as satellite remote sensing claim to provide the ultimate, efficient means of monitoring the Earth at increasing temporal and spatial resolutions, it seems appropriate to turn to this type of mechanical framework for providing objective analysis and policy support for environmental governance.

When understood historically and hermeneutically, the ‘environment’ can be seen as a physical, social and psychological milieu in which we exist and have power to affect or be affected by. This definition suggests a deeper appreciation of the role that human actions including the application of science and technology can play in affecting the environment. Indeed this notion places humanity as an integral part of the global ecosystem and suggests that studies of reflected and emitted electromagnetic waves can never tell the full story of human-ecosystem interactions at any given location or time.

A third definition of ‘environment’ comes from the critical perspective of power emancipation, allowing for nature to be seen as both material and spiritual, given and made, consisting of pure and undefiled elements and found to have both order and disorder.²³ In much of the literature on environmental politics, both academic and popular, it becomes clear that the term ‘environment’ conveys more of a material association, with ‘nature’ representing more of a spiritual component.

Bruno Latour (1993) has suggested that science and politics are representative, along with nature and society, as binary systems of knowledge. On the one hand, the modern notion of ‘society’ is a structure of social relations, regulated through politics. ‘Nature’ on the other hand is the representation of natural objects and landscape, regulated through science. Latour argues that the

²³ Smith (1984), pp.1-2

constitution of modernity is the structure of science and politics that keeps society and nature distinct and subject to regimes of representation by experts including politicians and scientists. While Latour's theory provocatively describes the state of separation between humans and nature, perhaps connecting these two disparate systems of knowledge and regulation are bridging technologies such as remote sensing. In the sense that digital scans of the Earth's atmosphere and surface have been used as scientific evidence to forecast the limits to human growth and development, this technology serves to connect Latour's two binary systems of knowledge, with science affecting political decision-making commensurate with how society has affected nature.

Placing the environment behind the lens of investigation, experiment and treatment offered by remote sensing also enables a consideration of ecofeminist perspectives such as that of Gillian Rose (1993) who conceived of the 'mirror and the Imperial Eye', a masculinist history prevalent in the history of cartography. Rose suggests that we need to think in terms of an epistemology of mapping as one in which the mirror "has been broken into a thousand pieces, each shard still reflecting, but without coherence, without the possibility of the universal view, without the possibility of [universal] control." While seemingly running counter-current to the technological pursuit of ever greater spectral, spatial and temporal resolutions of the Earth from space that may intensify a singular world view, the "shards" that reflect different "views" can also be conceived of as the metadata attached to images. Depending on the applications of digital Earth images and maps, universal control and masculine world views can be diffused into various channels of control, powered by the needs of society. Once again the lens of scientific enquiry extends from its binary relationship with nature to the realm of politics and society.

The choice of terminology and the form that policies take in support of certain applications of remote sensing can effectively limit the options for society in thinking about its role as an actor or player within the biosphere. Earth remote sensing is a powerful information technology but provides only pictures and data concerning the events and conditions of the biosphere.

Theoretically, 'pictures' can place human observers in the position of spectator rather than player, therefore allowing for the further conceptual separation of humanity from nature. To paraphrase Max Frisch (1957), 'technology can provide a means of so arranging the world that we need not experience it.'²⁴

The International Geosphere Biosphere Program (2004) has discussed the emergence of a growing body of research in the environmental sciences that finds this conceptual separation of humans and nature to be a critical problem in thinking about how to reduce the scale and intensity of human impacts to the environment. While interactions between environmental change and human societies have a long and complex history, spanning millennia and varying greatly through time and space, the Earth is now recognized as a single system, within which the biosphere is an active essential component. The activities of modern society are now becoming "so pervasive and profound in their consequences that they affect the Earth at a global scale in complex, interactive and accelerating ways; humans now have the capacity to alter the Earth System in ways that threaten the very processes and components, both biotic and abiotic, upon which humans depend."²⁵

In the critical environmental politics literature, the concepts of a total ecological and material throughput or an ecological footprint have been forwarded in anticipation that reducing such

²⁴ Frisch, Max. (1957). *Homo Faber*, "Second Stop," 1957 (author's translation).

²⁵ International Geosphere Biosphere Program (2004), p.6

phenomena at a global, societal or individual level to that of sufficiency is the key to a sustainable future.²⁶ These concepts require conceptual bridges to be made between environmental policies that regulate societal practices and the empirical scientific methods that measure these phenomena. The questions of lifestyle and societal consumption patterns that have such an important relation to the global environment do not readily connect to the realm of global governance that calls on technologies such as remote sensing to assist in environmental regulation. Indeed the crucial concepts of ecological footprints or throughputs are not readily measurable with space-based sensors. As Simon Dalby (2004) has explained, government policies that regulate the environment often do not address the appropriate concepts or engage them at appropriate scales:

“...the assumptions of regulation, as with so much of ‘scientific’ research, is that reality is specifiable in terms of stable entities. Precise surveying and territorial demarcations of such things as park boundaries produce knowledge and management practices that are antithetical to ecological complexity. The society that produces such knowledge and such assumptions of [a] precisely demarcable external environment is the carboniferous capitalism that is causing the problem in the first place.”²⁷

A predominant perception within the satellite remote sensing community is that the proliferation of cheap, accessible and increasingly higher resolution Earth imagery and monitoring data will provide a transparent and accountable means of detecting critical environmental changes, patterns of degradation and sources of pollution. In turn, if made widely available to a concerned international public or to multilateral regulatory bodies, this information could be used in addressing developmental issues such as sustainable food production or for verification and compliance of treaties such as the Biodiversity Convention or Kyoto Protocol.²⁸ Some theoretical concepts underpinning global environmental governance however, so seemingly ignore the local

²⁶ Rees et al. (1996); Sachs et al. (1998); Dalby (2004), p.5;

²⁷ Dalby (2004), p.4

²⁸ Kline et al. (2000); and Sherbinin (2000)

scales at which both development challenges exist and within which societal changes need to occur. This ‘globalized’ way of thinking and addressing problems may even serve to widen the conceptual separation between small-scale actors and their responsibility and involvement with environmental and development issues at larger scales.

As for the ability of satellite imagery to inform on global governance, it is also notable that humanity’s ability to monitor the entire world surface began to rapidly evolve during the same period of time that natural landscapes and ecosystems began a rapid rate of development and change. “While an untold number of forms of biological and social life are being destroyed in a brief span of time, a device is available to record what is disappearing.”²⁹ Like deceased relatives preserved in a family album, whose presence in images conjures up past anxiety and remorse while providing some comfort through reverie, perhaps the rising interest in EO for global environmental monitoring is related to an emotional response to the steady decline of pristine natural landscapes. Commenting on the unique capacity for satellite imaging to monitor such events as the 1991 oil well fires in Kuwait or the similarly devastating oil spills off Crete, Mike Kobrick of Radar Sciences, JPL noted that “just at the same time that man has become technological and powerful enough to really effect the global environment in a major way... we have also simultaneously developed the ability to monitor all of it.”

There may yet be a role for technologies such as Earth imagery to reconfigure how humans think about their individual role in society, including their individual consumption patterns, but this may involve less of a reliance on the large-scale application of technology and more contemplation toward the interconnectedness of human actions and nature at various scales. The following

²⁹ Sontag (1977), p.16

section will further address the potential importance of visual geospatial information in enabling a rethinking of space, environment and society.

3.3 The Power of the Visual

Little round planet in a big universe;
Sometimes it looks blessed, sometimes it looks cursed.
Depends on what you look at obviously;
But even more it depends on the way that you see.³⁰

The importance and power of imagery in influencing human cognitive processes is an important aspect of this study. Drawing on historical analyses of the visual arts including photography, the evolution of the spatial metaphor, and theories of visualization as applied to spatial data and geographic space, support can be found for the argument that satellite imagery should not be seen in isolation from the political and economic forces that influence the integration of such visually-based technologies into modern society. How images relate to conscience and to knowledge is of importance to a wide range of problems raised by the presence and authority of geospatial data in modern society.

As Susan Sontag (1977) has argued, all societies that have come to be known as *modern*, must be understood in terms of interchanges between reality and images of reality. More precisely, the perception of reality within modern society has become highly influenced by images and the widespread communication of images. Space-based technologies that have enabled Earth images to be broadly integrated into the minds and lives of individuals and societies – from corporate logos to technical backdrops in sophisticated resource management strategies – have also contributed to the influence that these images have. All human beings with the ability to see begin practicing some basic form of image-interpretation at an early age and television and

³⁰ Cockburn, Bruce (1991) from “Child of the Wind” © 1991 Golden Mountain Music Corp.

illustrated publications are all predicated on the ability of an audience to engage in the rudiments of image processing.

Visualization, as described by Alan MacEachren (1992), is an act of cognition, enabling humans to “develop mental representations [of the world that] create or impose order.”³¹ The communication of Earth imagery to a vast number of people made possible by satellite and information technologies has enabled the imagining of humanity in a trans-national and global context, unconstrained by political boundaries. This conscious or subconscious act of cognition, it can be argued, may be contributing to the conceptualisation, exemplified within post-modern international relations theories, of an ecologically interdependent world of collective human identity sharing similar physical and social spheres. This conceptualisation has historically given rise to environmentalism in general, and has increasingly focussed attention on global regimes as a means to address environmental and development issues.

An alternative mental representation of the Earth is based on the theoretical supposition that the act of image capture – whether on canvas, film or digital medium – can be understood as an appropriation of the object or landscape being imaged. As Glendinning (2002) has described, “the notion of owned-Earth originates in maps.”³² Literature from the visual arts also suggests that the act of image capture has a relationship to the subject much like knowledge has a relation with power. Much that can be said about photography can be applied to images in general, but the ‘realness’ of photography, the fact that the electromagnetic spectrum can be frozen in time and reproduced as a captured slice of reality, makes a camera or digital sensor an intensely powerful tool for communication.

³¹ MacEachren et al. (1992), p.101

³² Glendinning (2002), p xiii

According to Bruce Mau (2004) “our most developed cultural forms are practices of the visual” but society did not stop there. Digital imaging of the non-visible portion of the electromagnetic spectrum follows a similar process of ‘image capture’ pioneered by early photography. Instead of the visible spectrum being captured on physical media, materials sensitive to particular bandwidths of reflected or emitted energy capture the qualities of an object recorded in digital (binary) format. For consumption by the human eye, digital representations can be translated into ‘false colour’ composites and hundreds of shades of grey producing a visible image from previously invisible phenomena.

Images captured on film or through a digital medium furnish evidence of something. Indeed, along with printed and spoken words, images are the largest provider of knowledge people have about the world: past, present and even possibly, visions of the future. Whereas paintings and printed words are representations and interpretations of ‘reality’ and their influence throughout history have been profound, photographic images are not so much statements about the world as they are pieces of it, scaled to fit the purpose at hand. In the case of image-capture on a wide scale such as undertaken by remote sensing satellites, single objects, experiences and events are translated into views that can be seen and shared by many observers. Theoretically, this process can have a democratizing effect but on another level it can be seen as an imperialistic enterprise, conveying a singular understanding about the subject, an act that Arthur Kroker has described as the “psychological colonization of human perception.”³³ In addition, satellite image analysis is not a simple process but requires experts to derive useful information. Unlike painting and early photography, the goal of Earth observation from space seems to be to capture as many images as possible, maximizing ‘situational awareness’ for the viewer. Images today in both analog and

³³ as quoted in Bruce Mau (2004), “Massive Change” p.169

digital forms are increasingly ‘consumed’ through all forms of media and in particular through such realms as advertising and marketing. Satellite pictures are subject to similar patterns of image consumption, enabling humanity to feel that the world is more available than it really is.

Another element to the theoretical importance of images and their relationship to ways of ‘knowing’ is that capturing and reproducing images of something immediately confers a degree of importance to it. In tasking a satellite to image a certain Earth feature, importance is conferred merely through the expense and technological sophistication of the endeavour, particularly if one assesses the life-cycle of the technology from sensor design to final imagery product. While the process of image capture confers importance, that which is not imaged becomes less important. In turn, experience and knowledge becomes limited by the choices of image capture, particularly in a society or an application where a large dependence is placed on images for communication. Much along the lines of national topographic survey expeditions, territory that is left unmapped is left unknown and is trivialized, as is dramatically illustrated in the figure below which maps the size of countries in proportion to the availability of national topographic information in the mid-1990’s. As can be seen in the cartogram, the southern hemisphere has been largely trivialized and excluded from the realm of the known.

Figure 3.3-1: Cartogram of the worldwide coverage of topographic mapping (approximately mid-1990's). Each country has been distorted in proportion to the area of the map sheets of the most detailed coverage. The base value of 1:1,000,000 is assumed everywhere. (source: Nicolas Chrisman, *Exploring Geographic Information Systems*, John Wiley and Sons, 1997, pp. 258-259)

Similar results would likely be obtained by a global representation of the access and availability of remotely sensed imagery despite the relatively complete potential coverage that could be obtained. David Rhind (1999) has argued that the availability of digital Earth coverage, delivered to computer screens in near-real time is growingly feasible but he raises huge concerns over information quality for those that do have access, and issues of availability to those without the connection to the tools and know-how of the Information Age. Remote sensing satellites are frequently described as providing complete Earth coverage every 3-4 days using an assortment of sensor instruments, but the scale at which these observations take place is of primary importance in any discussion of the utility of the geospatial data to such topics as environment and sustainable development planning. Only very high resolution imagery can contribute to mapping products at the 1:50,000 scale, with availability, cost and processing time increasing exponentially with the resolution. Indeed, even high resolution images on the order of a few metres per pixel may not be

good enough to sufficiently support ongoing environment and development decision-making. Optical sensors additionally require cloud-free daylight conditions which are very restrictive constraints when considering the timely need for data on a repeated basis. In some cases, over-reliance on automated computer algorithms used to integrate digital imagery with other spatial data can provide outcomes that are worse than in-accurate – they can be absolutely wrong and inappropriate for the applications they are being put to.

The main point to be made here is that the great space projects of the past half-century and the satellite imaging technologies that are now pervasive and becoming more-so with the rise of commercial satellites have the potential to create the same highly uneven geography as the great state-led topographic mapping surveys of the previous few centuries, due largely to the ‘development gap’ and the uneven nature of the information economy. Other restrictions on access to appropriately-scaled geospatial information for developing countries are due to national policies in the developed world that restrict the distribution of imagery and data at certain resolutions, of certain locations, or to certain groups for a variety of strategic economic or security reasons.

With the advent of the Internet and global communications infrastructure, and particularly as a result of rapid automated digital image processing, the prioritization of what is to be imaged and marketed by private industry becomes a limiting factor in what becomes ‘known’. Through being imaged, something becomes part of an information system that is fitted into schemes of classification and knowledge, ultimately defining the “stuff of ordinary experience.”³⁴ When applied to remote sensing from space, it is clear that there are some serious implications for this line of thinking in how certain populations come to know and understand certain regions of the

³⁴ Sontag (1977), p.156

Earth. While many imaging satellites do obtain full Earth coverage, resources to capture each area of the Earth equally are not available due to cost, bandwidth availability, storage capacity of on-board computers and life-cycle of sensors. In addition, imaging satellites are still operating in the domain of the elite, much as the first cameras made in France and England in the early 1840's were large, costly, cumbersome and seemingly without clear wide-spread social or civilian applications.

An argument has already been made that images of the Earth provide a conceptual space for thinking about the commonly shared aspects of the biosphere. A world not demarked by borders and territories may seem the ultimate image to inspire post-Westphalian governance arguably required to find the common ground needed to address global environmental issues and reduce development gaps. The very nature of an image captured from space portrays a wide swath that can only be vaguely associated with national borders because of coastlines and other geographic features along which borders run. But theory from the visual arts provides a contrary position, suggesting that imaging technologies make reality manageable and opaque, creating a world which denies interconnectedness and continuity. Again, what becomes known about the world is what is accepted of what has been recorded. *Knowing* the world as it looks may indeed be the opposite of *understanding*, which requires further enquiry in a multitude of dimensions. When remote sensing imagery is used in time-series, connected to adjacent images to create an inclusive framing of an issue or area such as an entire forest or watershed, a much deeper level of knowledge can be provided that more closely relates to an understanding of the systems in play behind the image.

While satellite Earth imagery can be distinct from regular photography due to scale, perspective and spectral details, the human element of *seeing* a final image is quite similar. While a viewer may be aware of the reality being depicted and is fascinated by the detail, there is also the possibility that the viewer will passively detach from an image considered in an isolated fashion. As with photography, a satellite image of the Earth will always be an object in a context. A surrounding discourse is necessary to invoke further emotion or understanding about a particular Earth image or about the practice of Earth imaging in general. This discourse is quite often contained in policies and marketing efforts that pursue greater use of satellite imaging technologies, and in the specific processing, enhancement and placement of images. The image and the conceptualization of the space being represented will change depending on the specific needs and interests of the image promulgator and whether it is used in a military planning document, a brochure on sustainable agricultural practices, or a transportation logistics strategy. Susan Sontag would argue that each of these situations suggests a different use for an image, but none secure their meaning. The meaning is the use, and in this way the proliferation of Earth imagery can be seen to contribute to an erosion of the meaning, a “parceling out of the truth into relative truths which [are] taken for granted by the modern liberal consciousness.”³⁵

3.4 Environmental Gazing: One-World and Whole-Earth Discourse

To be applied in this research project is a body of theory that concerns itself with the relationship that power and knowledge have with images and cognitive processes associated with visualization. While this is a traditional theme in many aspects of geographic enquiry, it is particularly relevant when the subject of the images relates to human livelihoods as they do when images depict ecological conditions on Earth. When the first single-frame colour whole-Earth image was

³⁵ Sontag (1977), p.106

returned from outer space along with the emotional eye-witness accounts representing the ‘astronaut’s perspective’, Earth was immediately contextualized in the imaginations of millions as a fragile blue sphere suspended in isolation in the vastness of space. This singular image and the accompanying experiential accounts had significant historical impact and a strong supportive effect for the burgeoning environmental movement that formulated during the 1970’s.

In 1972, Apollo 17 astronauts photographed a view of the Earth from 21,750 nautical miles above its surface that would become a singularly important symbolic representation of the planet. Image AS17-148-22727 as it was then classified, captured “center frame and with perfect resolution, the full terra-aqueous disk without a solar shadow or terminator.”³⁶ The whole Earth – geography’s principle object of study – had been photographed by a human being. Denis Cosgrove (1994) has studied this “Whole Earth” image along with the similarly important image classified as AS8-14-2383 but better known as “Earthrise”, captured in 1968. Cosgrove’s analysis establishes a theoretical link between geographic imaginings of the Earth in pre-modern times and the power of such images in reconstituting, “a repertoire of sacred and secular, colonial and imperial meanings.”³⁷ Cosgrove argues that powerful visual representations of the Earth have played a significant role in the self-representation of the post World War II Western world, particularly in the United States. These representations and the space missions that made them possible have influenced the international identity of the US and provided a focus for its geo-cultural mission in the modern age.

The symbolic meaning of images such as “Whole Earth” and “Earthrise” are now contested in post-colonial and postmodernist discourses, owing to their totalizing effect through a “One-

³⁶ Cosgrove (1994) p. 270

³⁷ Ibid., p. 270

World” Western gaze and the placement of humanity at the centre of the sphere of consciousness borne of technology. But the presence of increasing quantities of Earth imagery from remote sensing satellites and their wide-spread utility in many applications by a diverse number of actors requires a renewed examination of the discourse surrounding Whole-Earth and Earthrise, and the power of such images to direct emotions and thinking about the planet into what has been alluded to in the title of this dissertation as competing efforts to ‘secure the Earth’.

From Aristotle and Ptolemy to Copernicus and Galileo, astronomical and cartographic positioning of the observer at sufficient distance to see the spherical Earth has prefigured the production and early reception of the Apollo space images through existing discourses of Divinity and Empire.³⁸ *Seeing* the Earth from a distant, objective and penetrating gaze makes a symbolic *mastering* of the object possible in the human mind. Much as telescopes and celestial models were produced for the noble classes of Roman, Greek and far earlier civilizations, world maps and atlases were popularized through their originally lavish production for an educated European bourgeoisie. Earth views have always maintained the ability to totalize the human experience into a singular object, thus creating the subconscious or conscious sense that control over its destiny could be exerted by human actions.

The Earthrise image was first broadcast to televisions across North America during Christmas 1968 through the use of newly available satellite communications technology. The spiritual relevance of this photograph during the Christian holiday was not missed, particularly when the image represented a paradigm shift from the typical placement in the night sky of the Moon rising with the Earthrise in its place. This image provided a context for deep emotional and philosophical reflection about the planet, arguably providing initial impetus for a reformed

³⁸ Jacob (1992) as referenced in Cosgrove (1994) pp.271-294

collective view of the world. The widespread use of this image in popular media since 1968 suggests its persistent societal impact as an iconic image of humanity.

Figure 3.4-1 Earthrise Image # AS8-14-2383 © NASA

Heightening the societal impact of the Earthrise image was the accompanying discourse initiated most poignantly from the astronaut who took the photograph, William Anders:

The Earth looked so tiny in the heavens that there were times during the Apollo 8 mission when I had trouble finding it. If you can imagine yourself in a darkened room with only one visible object, a small blue-green sphere about the size of a Christmas-tree ornament, then you can begin to grasp what the Earth looks like from space. I think that all of us subconsciously think that the Earth is flat or at least almost infinite. Let me assure you that, rather than a massive giant, it should be thought of as the fragile Christmas-tree ball which we should handle with care.³⁹

³⁹ William Anders as quoted in Cosgrove (1994), p.284

The metaphors invoked in Anders' description can associate Earth with a trivial object in the emptiness of space, or with something more spiritual and emotional that must be embraced and cared for.

The Whole Earth image, captured by the last Apollo mission on its way to the Moon is, as Cosgrove explains, “intensely geographical, drawing on powerful conventions of cosmographic and chorographic representation in the Western geographical imagination.”⁴⁰ In this line of thinking, the image of the Earth makes possible an entire range of new interpretations about it.

Figure 3.4-2 Whole Earth Image #AS17-148-22727 © NASA JSC

⁴⁰ Cosgrove (1994), p.275

It is perhaps with some irony that the Whole Earth image, so popularized and wide-spread in its application in Western advertising, corporate logos and support for global statements about any number of issues, has the African continent as its principle subject. Cosgrove further describes the Whole Earth image:

22727 locates a perfectly circular Earth image within a square frame. When the terrestrial disk is centered by minor cropping of the original shot, the image attains the mandala form of circle and square whose completeness and geometrical unity are familiar from the cross cultural history of cosmic images and which [is] regarded as a key archetype.⁴¹

With the Middle East bracketing the African continent to the north, keen observers are reminded of the “oldest” part of the world in the Western imagination. Antarctica brackets the view of Africa to the south, symbolizing perhaps the “youngest” part of the known world, a continent symbolic of the concept of the commons.⁴²

Africa itself, widely understood as the geography from which early *homo sapiens* first emerged is given an unusual centrality to the exclusion of the Northern and Western continents. Western notions of continental scale are challenged with the Whole Earth image in a similar way to how the Peters cartographic projection of 1977 remapped the world’s land areas in relative terms, enabling a revisualization of the world from the more commonly used Mercator projection used extensively for marine navigation dating back to the 1500’s. In the Peters projection, the cartographic technique used to emphasize the extent of the African continent trivializes the size of Europe, the Americas and Australia. More recent cartographic tricks have been used to map the world according to national income, availability of topographic information (see Figure 3.3-1) and a host of other variables which can almost exclude the continent of Africa to the overwhelming presence of wealthy regions. The Whole Earth image, whether intended or not, served to

⁴¹ Cosgrove (1994), p.276

⁴² *Ibid.*, p.278

exaggerate the presence of the “other” in the Western imaginary, and with its lack of coordinating features such as borders, graticule and text, commentaries have suggested that the image served to liberate the Earth from its cultural constrictions, allowing for a more holistic representation of the planet in the Western gaze.

In spite of the Apollo Mission’s purpose – to explore the Moon and discover the universe beyond Earth orbit – it is remarkable that the lasting result of the missions, photographs and chronicles was the profound interest in observing Earth from space. It can be argued that while much of the cost and effort placed in space exploration initiatives has been focussed on exploring *outer* space, the end result and resulting technologies inevitably focus their attentions *inward* toward Earth. The thousands of human-made satellites currently orbiting the Earth is evidence of this, particularly since most of these objects have at one time or another either imaged or reflected signals to and from Earth.⁴³ Only comparatively rarely have space ventures focused on the solar systems beyond Earth orbit. Images of the Earth have now become symbolic at times of Western imperialism and American empire, deployed in all sectors from newspapers to transportation, often without an appropriate subtext to describe their meaning. Earth-views have also subtly become representations of global citizenship such as the intended symbolism of the United Nations flag.

When considered in their historical context, it is not surprising that Earthrise and Whole Earth spawned an entire series of discourses in the scientific, academic and civilian worlds surrounding space exploration and technologies that created contrasting perceptions of the role of modern science and Western power in world affairs. Historically, the Cold War rivalry between East and

⁴³ According to the Online Index of Objects Launched in Outer Space, almost 3,000 human-made satellites are currently operating in Earth orbit (UN Office for Outer Space Affairs www.unoosa.org/oosa/osoindex.html) [Nov. 12, 04]; Cleminson (2004) estimates that over 8,000 objects – operational and non, are located in orbit.

West, the debut of the space race and the surge of national identity-building through efforts to be industrially, technologically and ideologically superior provided the context in the US for triumphant celebration of its space achievements, supporting a singular, imperialist, masculine and Christian-spiritual dimension to the American dream.

In contrast though, Michael Collins' personal account of circling the dark side of the Moon during the Apollo 11 mission reveals much of the emotional basis for a growing sentiment of environmentalism in the US. His account of the Earth as a "tiny pea, pretty and blue" that made him feel "very, very small" places an emphasis on *feeling* rather than *seeing* the Earth and provides an overwhelming sense of the isolation that could be felt by humanity de-coupled from its life-support system. Further, the astronaut's perspectives suggested a new level of humility with which humans should interact with the vulnerable and fragile "Whole Earth", a discourse describing human-environment attachment. Daniel Deudney (1999) has even suggested that a sense of deep affinity with and hence responsibility for the Earth offers such a unifying sentiment that a substantial revision of our understanding of state politics could result through such discourses.

The four years separating the Earthrise photo from the Whole Earth image saw some of the most significant critiques of the US space program and the emergence of modern environmentalism as a mature political form of expression. The first 'Earth Day' was celebrated in the US in 1970. James Lovelock's Gaia hypothesis emerged in the 1970's along with other prominent environmentalist works by Aldo Leopold, Fraser Darling, Paul Ehrlich, Barry Commoner, the Club of Rome and a host of eco-feminist literature. Rachel Carson's earlier work *Silent Spring* was increasingly recognized as a fundamentally important contribution to environmental critique.

All of these emerging views supported self-questioning about the limits to growth, population pressures, global pollution, poverty, resource management and social justice, suggesting “an Earth despoiled rather than adorned by human achievement.”⁴⁴ In this context, global environmental change research established a mainstream foothold in the sciences and had a role to play in the formulation of the first global environment conference: the 1972 United Nations Conference on the Human Environment in Stockholm. The Stockholm conference represented one of the first prominent examples of how academia and NGOs could not only respond to politics but could instigate politics in the environmental realm.⁴⁵

While there is rarely a physical human eye behind the lens of today’s images of the Earth, there is the implication of a constant witness to events and conditions on the ground. This witness sees the Earth surface through an astronaut’s perspective that is, as Cosgrove explains, distinctly modern, scientific, objective and technically masterful. The massive Earth Simulator Centre of Japan for example, dedicates itself to the processing and rendering of complex Earth data from satellites and environmental models to produce myriad global portraits each describing conditions such as radiation, oceans, weather and earthquakes. As the Earth Simulator Centre’s Director-general Tetsuya Sato has described: “With Earth Simulator, we are now able to understand the Earth holistically, with all factors entangling together at once, from microprocesses of clouds or snow to macroprocesses of atmospheric circulation, just the way Earth is.”⁴⁶

With an incessant focus on studying human actions, providing communications and the monitoring of environmental conditions, much could be said about the self-interested human,

⁴⁴ Cosgrove (1994), p.287

⁴⁵ As discussed in the panel discussion: “Global Environmental Governance: Does Anybody Care?”, held during the Annual Convention of the International Studies Association, Montreal, March, 2004.

⁴⁶ As cited in Bruce Mau (2004) “Massive Change” p.102

capable of obtaining a view of itself from a God-like perspective with all the spiritual and emotional connotations this could provide, but still pre-occupied with surveillance of the “other” and a desire to project control over events on the ground. The presence of today’s growing suite of space-borne sensors monitoring the Earth from above is perhaps representative of the final convergence of the interlocking discourses of religion and military rule that have long structured the imperial imagination in the West and is a full representation of the technological imperative of modernity.⁴⁷ The key will be to ensure that these interlocking discourses converge in public policies that enable society to maximize the societal benefits of modern Earth monitoring technologies while minimizing the costs.

3.5 Earth Viewing, Fast Seeing and Technological Modernity

While the role of photography in influencing the Western geographical imagination has previously been discussed, there is an important new element to photography’s influence when the astronaut’s perspective is implied as in *Earthrise* and *Whole Earth*, but with modern sensors, image processing techniques and automated algorithms that remove the accompanying personal and emotional viewing context.

As bureaucratic and judicial acceptance of photography in the late 19th century fostered the assumption that cameras do not lie, cameras and sensors capturing images from the air and space in the ensuing decades have had even more credibility in society for providing documentary evidence of the state of the world:

The airborne camera simultaneously realized geography’s mission – to provide accurate description of the entire global surface – as it bore witness to a new perspective on that surface: ‘the airman’s vision’ ... served as the foundation of twentieth-century geopolitical thought.⁴⁸

⁴⁷ Cosgrove (1994), p.279

⁴⁸ *Ibid.*, p.279

While the important issues of privacy that are raised by the possibilities of high resolution Earth imagery is beyond the scope of this discussion, there is a disconcerting ease with which photographs from space are taken and perhaps a lack of accountability for their use. Indeed, calling for accountability may seem a strange concept when the images are by their namesake, ‘remotely sensed’ rather than human-triggered, but the important requirement for image interpretation leaves much to the processes of human cognition. While high resolution imagery appears to reduce the dangers of first order cases of mistaken identity, there exist opportunities for various imagery exploitation errors to occur which are not unique to any particular group of user.

Despite the inadvertent authority of the camera’s results and the suggestion of a very tenuous relation to knowing, it is clear from the earlier discussion of Earthrise and Whole Earth that space-based photography gives a tremendous boost to the cognitive claims of sight because it so greatly enlarges the realm of the visible.⁴⁹ The use of sensors which use radar and multi-spectral scanners to detect objects and phenomenon not visible to the human eye, and computer models that can portray three-dimensional representations and “fly-throughs” of a particular geography mark an even more profound ability for cognition to be enhanced to serve particular uses.

The speed at which images and data can be captured from outer space and processed can also potentially lead to their indiscriminate use. As Alvin Langdon Coburn in 1918 declared the camera to be an instrument of “fast seeing”, the same term even better describes satellite remote sensing in the Information Age. The rapid global flow of information depends to a great extent on visual information. This flow has been described as the ‘cult of the future’ (of faster and faster seeing) and the pace of data collection versus knowledge derivation in modern society has been

⁴⁹ Sontag (1977), p.116

described as a culture ‘drowning in information but starving for knowledge’. Overly technocratic approaches to viewing and sorting the world according to geographic elements and analysing issues at increasingly smaller spatial scales without examining qualitative factors at a similar level may obscure the nature of problems being addressed. The speed of information flow can easily overtake cognitive abilities to process or comprehend individual issues. A growing dependence on powerful, centralized data processing and information collection institutions may result, with the identification of issues and priorities tending to conform to the interests of the centres of power and authority.

While philosophers since Plato have tried to reduce our dependence on images by evoking the standard of an image-free way of apprehending reality, modern society may in fact prefer the image to the thing and the representation to the reality. Indeed, it has been argued that a society becomes *modern* when one of its main activities is producing and consuming images: “when images that have extraordinary powers to determine our demands upon reality and are themselves coveted substitutes for firsthand experience, [images] become indispensable to the health of the economy, the stability of polity, and the pursuit of private happiness.”⁵⁰ Computer-based global inventories of Earth images and data are now becoming available through the Internet to those with the financial and technical ability to use them. Imagery derived from remote sensing satellites conforms out of necessity to ordered spatial concepts that require certain modalities of thinking about geographic space. In consideration of the swaths of sensor coverage and the pixilation of digital imagery, satellite sensors themselves can be seen to have assisted in the social construction of landscapes which are bounded and packaged in preparation for development or resource exploitation. Wherever a major portion of territory remains uninhabited, satellite-based

⁵⁰ Sontag (1977), p.153

land-use classification maps render each block, concession, swath or pixel subject to some form of control or potential development and consumption. Even over international waters, satellite imaging can detect oil seeps which generate interest and investment in oil exploration activities in those regions.

Despite the emotional accounts of the early space gazers and explorers that placed planet Earth at the center of the frame of enquiry, high technology has assisted in a theoretical and perhaps symbolic mastering of the Earth. The relevance of this discussion becomes clear when the two predominant discourses emerging from early Earth viewing again emerge in policies that guide the commercial development of space-based Earth observation technologies. Each discourse, representing either ‘environmental detachment’ through the strategic imperial, military, or economic objectives of the sovereign state or ‘environmental attachment’ through commons-based approaches to planetary stewardship, draws upon and extends ideas of human territoriality that have deep cultural, historical and geographical roots. ‘Environmental detachment’ has its roots in religious, military and dominating political power structures, but is now expressing itself in a global economic and technological order that may challenge traditional notions of sovereignty by extending power to private multinational corporations. ‘Environmental attachment’ on the other hand is a representation of the spiritual link between humans and landscape, form and function, space and place, but it too calls for a form of universal order – a potentially homogenizing view of a global community which itself falls under much scrutiny when subject to post-modern analysis and critique.

Clearly, there are limitations and problems in relying on any one set of technologies to monitor and describe the Earth, particularly when such technologies are controlled by elites. If emphasis

is placed on ensuring that a “dignity of difference”⁵¹ is maintained between different ways of viewing the Earth, with regulatory frameworks enabling a balance between space technology’s application for private versus public gain, there may be much promise for both discourses to further the concepts of environmental responsibility, global citizenship, stewardship, governance and a post-modern society that recognizes interconnectedness and interdependencies between humanity and nature.

3.6 Issues in the Transition to a ‘Digital Earth’

Much of the attraction of digital spatial technologies and remote sensing images is the colourful map applications that appear on computer screens, or on two-dimensional printed representations of the Earth. On screen, images can be manipulated and optimized to portray certain features with the touch of a mouse. Digital maps or classified digital images of the Earth communicate their information through the visual sensory channel. The eye-brain system uses complex rules of visual association that are well understood by cartographers and map-makers, less-so by casual users of modern ‘black-box’ software that have enabled the production of poorer-quality maps and images, more cheaply, and in greater volume than ever before.⁵² Recognizing this effect of the visual cognitive processes of the human brain coupled with a transition from analog to digitized geographic space becomes critical when considering how often Earth images and maps are used in efforts to influence public opinion, policy and consumer attitudes. As noted earlier, Earth imagery, various forms of geospatial information and textual references are used for secondary purposes of advertising, logos, flags, travel emblems and basically any form of media

⁵¹ this term is taken from the primary theme and book title of Jonathan Sacks’ 2002 *The Dignity of Difference: How to Avoid the Clash of Civilizations*, London: Continuum.

⁵² David Rhind, in Pickles (1999)

that is used to entice the viewer or reader into a sense that the scope of the subject being pursued is global in reach.

The paradox presented by the above is that the same world that is witnessing a rapid transition to the digital realm, providing global access to simple cartographic representations of the Earth is the same world that is in need of meaningful, skilful use of geospatial data to build cognitive bridges between Earth ecosystems and the spiralling out-of-control consumption patterns of modern civilization. Michael Goodchild (1999) has described how the changing technology of the past few decades has enabled the acquisition, transmittal, storage and use of virtually every kind of information used by humans, to be performed using coded series of 0's and 1's – the term coined for this phenomenon being the 'digital transition'. Much has been said about the effects of this transition, ranging from issues of privacy to the over-reliance on information not actually written down anywhere on paper or stone. Moreover, the ability for massive amounts of information to be transported and used around the world is inextricably linked to the evolution of the global economy, which has seen a trend toward the production of networks of power and knowledge structures away from traditional centres of control. In considering this trend, it becomes important to examine certain technical and policy-related problems posed by a "Digital Earth".

Of initial concern with reliance on digital representations is that the data used to produce Earth imagery can be ideally suited for deception. As mathematical algorithms manipulate digital data through the computerized image construction process, virtually anything can be altered or emphasized in digital imagery and information without easy detection. As Steven Livingston (2001) explains:

Mathematically altering the value of the pixels alters seamlessly the representation.
"Since it is purely a mathematical process, the source images can be altered

fundamentally and undetectably before and/or during their production.” Elements can be added or subtracted, changed in color, brightness, or contrast. Changes are made not by altering the computer code that produces the image, and not in the image itself as in analog manipulation. In fact, it is more accurate perhaps to say that no image exists beyond the mathematical equations that create a particular array of pixels. The equations are the image. Therefore as computer processors become faster and more powerful, so too does the ability to alter digital information.⁵³

When the previously discussed concept of “fast seeing” is also included in this discussion, it becomes even more alarming to note that digital data streams can be converted and manipulated into imagery in near real-time, leading to a series of legal conundrums and policy implications that are beyond the scope of this research but do suggest a need for regulatory involvement by responsible authorities.

Another set of issues have been identified by Helen Couclelis (1999) when she argues that, “the interactive coupling of a human intelligence with the computational power of a machine [produces] intuition-boosting cognitive appeal [for] the visual representations produced through that interaction”⁵⁴ This is precisely the challenge with remote sensing imagery as it is with the use of all digitally-processed geographic data. On the surface, simple Earth images seem devoid of any vast implications for society. Indeed the realist view is epitomized by the transparency and objectivity of a ‘real-world’ representation or photograph. The process that creates the representation is however an interactive process channelled through a series of technologies, human interface devices and individual decisions. The images are then used by large numbers of different groups of people working either cooperatively or in an adversarial manner.

⁵³ Livingston, Steven (2001) “Transparency or Opacity? Technology and Deception Operations”, paper presented at the International Studies Association Annual Convention, Chicago, 21-24 February 2001 with quotation from Don E. Tomlinson, *Computer Manipulation and Creation of Images and Sounds: Assessing the Impact*, Washington, D.C.: The Annenberg Washington Program, 1993.

⁵⁴ Couclelis (1999), p.19

As Couclelis further argues, the step from representation to ontology in geospatial representations of the world is a small but crucial one. From seeing the world as a *representation* to *thinking* that the world is actually as it appears, processes of human cognition need to be understood in the context of the development and application of the very visually-oriented technologies represented here by remotely sensed images and GIS. Much has been studied about traditional cartography and its impact over history on human conceptions of the world around them, but where the map often defined the territory, the images now determine what exists or at least what is important of what exists. As the design specifications of the graphical user interfaces of modern image processing software indicate, the WYSIWYG (What You See Is What You Get) principle applies. On one hand, if you see it, it must be there (commercial satellite imagery was used to suggest the case for a US invasion of Iraq in 2003 based on the implied presence of mobile chemical weapons labs), but on the other hand, if you don't see it, you are lead to believe it doesn't exist (famine and issues of human security in sub-Saharan Africa). Both extremes have now become easily possible with the touch of a keyboard and a knowing or unknowing lack of skill used in satellite image processing coupled with a persuasive accompanying discourse.

While the final images may appear as objective as photographs taken by a hand-held camera with light-sensitive film, satellite images are increasingly abstract and digital representing a series of millions of 0's and 1's transmitted over space and time, re-assembled on Earth, configured, geo-coded and "corrected" by computers used to classify, optimize, ortho-rectify, assign colour combinations and enhance imagery for viewing by humans in the visible range of the electromagnetic spectrum. In the end, it is only one given representation of reality that persists in the minds and thoughts of the thousands of down-stream recipients of the image. What is included and what is excluded becomes the important issue. While some have cautioned that the

visual is over-emphasized in digital cartography (over the non-visual aspects of society and geographical space such as political and economic conditions), sensors on satellites have also brought much of the 'invisible' into the human visual realm such as radar imaging of snowline recession on glaciers as an indication of a warming climate, or algorithms applied to multi-spectral scans indicating pollutant concentrations at ground level.

Stephen Hall (1993) has argued in *Mapping the Next Millennium* that we are in the middle of “arguably the greatest explosion in mapping, and perhaps the greatest reconsideration of ‘space’ (in every sense of that word) since the times of Babylon”⁵⁵ Al Gore, in a speech given in 1998 challenged Americans to imagine a young child accessing, from a variety of computer interfaces, all types and scales of geo-spatial, historical, political and social information about the world.⁵⁶ Gore’s “Digital Earth” speech served as a rallying cry for cooperation between disciplines and interests in the production of an Earth-information system that operates over various scales, resolutions, data formats, communication media, interfaces and representational modalities, all in an immersive virtual environment. Contrasting this to the traditional notion of information flow in an office setting employing the use of desktops, files, windows and even ‘recycle’ bins, emphasized the analog-to-digital crossover and the use of metaphors in computer applications. While on-line atlases, computer cartography, visual simulations and digital reconstructions of past and present biogeochemical processes such as Japan’s Earth Simulator can not ultimately create real-world geographical experiences, much effort is taking place to make the Digital Earth as close an approximation to the ‘real’ as possible. In attempting to engage in discussion about the power of space technologies in modern society, it becomes evident that to date, most geographical

⁵⁵ Hall (1993), p.8

⁵⁶ Gore (1998)

representations have been terrestrially and regionally-based, leaving the holistic frames of view which are possible from satellites relatively “unmapped” in the human consciousness.

Much of the academic and popular literature discussing the impacts of new technologies on society refers to the concept of transformations, seen to be underway in a variety of areas including the meaning of sovereignty, the nature of international relations, and in the roles of private and public sectors including NGO’s and civil society in forming new modes of governance to address societal problems. One of the driving forces behind all of these transformations has been the ‘information revolution’ that has transferred the potential of the scientific method to the cultural sphere. As Mau (2004) describes, “as the limitless virtual world becomes larger and more powerful, and access to information – the true catalyst for change – increases exponentially, so too do the opportunities.”⁵⁷

The ever-expanding cultural accumulation of knowledge has been viewed as a promising outcome of global access to information, but the transition to a world interconnected by information and powered by “fast seeing” technologies controlled by private interests also raises some concerns. Michael Goodchild (1999) has argued that transitions are “about a certain type of reading of the dynamics of political economy ... presuppos[ing] a particular conception of History that is progressive and usually singular and linear.”⁵⁸ Goodchild’s suggested strategy for managing the emerging digital transition may prove useful for thinking about management of the private-sector EO industry. First, Goodchild saw a need for clear principles to be established to guide the mass communication of geospatial information. While private market forces will likely drive the

⁵⁷ Bruce Mau Design and the Institute without Boundaries: Exhibition at the Vancouver Art Gallery (2004), “Massive Change – the Future of Global Design” – see Mau, B. (2004) and www.massivechange.com

⁵⁸ Goodchild, Michael F. (1999). “Cartographic Futures on a Digital Earth” in Keller, P., ed. *Touch the Past, Visualize the Future*, Proceedings of the 19th Conference of the International Cartographic Association, Ottawa, August, 1999. v.1 pp.1-35

production of standards out of economic necessity, more than one path to the future should be possible. Goodchild cautioned that patterns of uneven social development and power relations are inherent in any new “transition” but when these uneven developments are obscured from view, a fetishised approach to “progress” can raise serious questions about how progress for some results in disadvantage for others. Goodchild suggests that establishing standards and norms within the geospatial industry will require oversight and regulation from governing bodies.

Second, Goodchild underlined the importance of articulating a vision of what the mass communication of geographic information might mean at some point in the future. As the world rapidly organizes itself according to form, function, economics and the distribution of structures of power and influence, a need to plan and direct the applications of powerful technologies such as remote sensing exists so that it may address the most pressing needs of society rather than pursue the narrow self-interests of elites. The wide-scale recognition of the power of such technologies to affect decision-making and discourse about security and environmental issues in particular, may avoid any significant reliance on one hegemonic producer or controller of geospatial technologies.

Third, Goodchild expressed the view that research will be spurred on by both human curiosity and a desire for economic gain, necessitating again the need for some form of accountability to ensure the protection of the wider public interest.

Brian Harley (1989, 1990) has studied various implications of the ‘digital transition’ and the new universal features of market capitalism and representative democracy in his essays on ‘deconstructing the map’ and the ‘power of the map’. This research reveals that “behind the pretensions of objectivist and universalist cartography and GIS lay a variety of culturally

determined and socially conditioned interests.”⁵⁹ Denis Wood (1993) has similarly shown how the “power of maps” reside in political and social power as well as in the technical capacities of the project.

Vincent Mosco (2004) has argued that technologies have emerged throughout modern history accompanied by a series of social myths concerning their power to induce and affect fundamental change. The telegraph and telephone, Mosco argues, were supposed to annihilate space and time, enabling any person within the reach of the wire network to communicate instantaneously with others all around the world. Radio and television signals were touted as offering the end of history as a new social order took shape, bringing the world together through the sharing of knowledge. Other myths have been propagated about the end of geography and politics resulting from the conquering of distances by telecommunications and transportation and the bringing of power centers closer to the people through the Internet. The important finding of Mosco’s research is that while myths persist, their mere existence has influenced actual transformations in society, impacting most profoundly when, “the technologies become banal – when they literally (as in the case of electricity) or figuratively withdraw into the woodwork.” Remote sensing satellites and the geospatial information and imagery they convey to the Earth are perhaps a unique set of technologies that are integrated into society in various invisible ways, from the unseen orbiting machines themselves to the way that geospatial data and imagery find their way into a vast array of maps and mapping technologies that power decision-making on the Earth. The very banality of the map as a tool in society, despite the ongoing intrigue with the Earth image, suggests that it is very powerful indeed, requiring of some form of guiding principle for its continued application.

⁵⁹ Brian Harley as quoted in Pickles (1999), p.17

Numerous critiques of spatial information systems by geographers working from the social theory perspective (Taylor, 1991; Pickles, 1995) have urged practitioners to acknowledge how certain design features, logic structures and visualization techniques inherent in these systems prejudice certain representations of the world over other alternatives. In addition, issues of access and control over information have been highlighted not only for their ability to filter out alternative forms of representation, but for how the knowledge, needs, desires and hopes of marginalised social groups could be adequately addressed in decisions utilizing these technologies.⁶⁰ The paradox is that emphasis has been placed on the transparency aspects of a global geospatial industry, urging that democracy and access will be the norm rather than the establishment of narrow control structures. Earlier research into this industry by Pickles (1999) has claimed that the diffusion of the technology, access to its use and opportunities for new development are increasingly in the hands of state bureaucracies, large corporations and research centres normally concerned with military and strategic planning.⁶¹

From the above summary of research into policy issues and notions of power, knowledge and control with respect to geo-spatial technologies in a global economy, it becomes clear that how governing policies and “rules of the road” for the geospatial technology sector are written and interpreted is of primary importance in limiting the potentially ‘bad’ outcomes of these technologies, while emphasising the ‘good’ aspects to society.

While Goodchild’s principles for guiding the mass communication of geospatial information are helpful to policy-makers, recognizing the power of discourse is also essential. With the technological elites heavily engaged in policy formulation in support of their own business goals,

⁶⁰ Couclelis, (1999), p.16

⁶¹ Pickles (1999), p.18

how the images and information emanating from the EO industry affects policy decisions becomes paramount. Much of Michel Foucault's theoretical works on discourse analysis can be used in the discussion that follows, while language and imagery work together within the growingly expansive reach of communication and information technologies.

In terms of language, of initial interest is the popular use of the term "remote sensing" within a literature that promotes the development and deployment of satellites to watch over the Earth. An alternative term used traditionally by military and intelligence organisations is "surveillance", a subject much studied by Foucault. A post-modern critique of real-time full-spectrum Earth monitoring or surveillance via satellite might compare this technology to Jeremy Bentham's *Panopticon* – a centralised structure used to maintain societal order through a population's subconscious awareness that their activities can be surveilled at any time. An automated digital world can be conceived as oppressive. Observation by corporate and governmental organizations comes in literal forms through cameras in public spaces and electronic monitoring of workers, but it also has a more figurative element in personal data-monitoring by the likes of credit agencies and insurance companies. Slight modifications of terminology do change the perception of technology as serving the 'public good' or as invasive, controlling and oppressive. The coupling of visualization processes and discursive practice in pursuit of one or more competing world-views can be a subtle but overwhelmingly powerful force in influencing the trajectory certain industries have and in constructing human understandings of the Earth, its processes, and society's role in influencing these processes.

3.7 Geopolitics, Geophysics and Global Cooperation

Political theorists have envisaged forms of global governance in which actors at various levels interact and react to each others' actions in support of the common good. This 'common good' governance could presumably rely to a great extent on space technologies to inform on global issues of importance and to verify compliance with established global norms. The historical strategic imperative to know the 'other' has however focused more use of space technologies on military uses than on providing holistic global world-views. As such, satellite observation has primarily served as a strategic enabler, enhancing the power and control of sovereign states to pursue their own interests.

Alfred Thayer Mahan in his geo-determinist treatise *The Influence of Seapower Upon History* argued that technologies that can take advantage and disperse the power implicit in geographic position, could be paramount in enhancing state power. Mahan recognized that the geography of the Earth's oceans, while a "wide common", also provided natural corridors of trade and "chokepoints", which if controlled, would realize the controlling entity great wealth and power. Mahan's call for the US to create and control the Panama Canal following the British precedent of constructing the Suez Canal to link its Mediterranean and Indian navies was a means of creating chokepoints where they did not exist naturally in geography.⁶² Mahan's strategy has now been theoretically applied to outer space in US defence doctrine out of recognition that space technologies are fundamentally important tools for maintaining economic and military dominance in the Information Age. As Vipin Gupta (1995) has argued, "just as the US military has a history

⁶² Dolman (2002), p.36

of protecting US ships on the high seas, it may have to take on new defence commitments to counter future threats against US property in space.”⁶³

Friedrich List and Halford Mackinder represent other early geo-strategists who acknowledged the historical importance of sea power but who saw the railroad as another technology influencing power-relations, expressed through geographic control. List saw a national rail network as the “cement of German unification, changing the strategic position of Germany from a beleaguered battleground ... to a defensive bulwark.”⁶⁴ The military importance of rail power that List described in the early 1800’s was later validated in the US Civil War and again in the First World War. Mackinder’s worldview saw railroads as a means to consolidate European world-dominance through empowerment of land resources over those of the sea. Geopolitical theories involving strategic application of technology to affect power relations suggests much for the domain of space.

Following sea and rail technologies, airplanes and then missile technology came to bear heavily on international relations. Alexander De Seversky, an engineer and US businessman, advocated powerfully for the US to commit to air power as the backbone of its strategic defences, using an azimuthal equidistant map to help US military strategists visualize the proximity of the Eurasian landmass to North America.⁶⁵ De Seversky’s maps led to policy in support of constructing the Defence Early Warning (DEW) radar line across northern Canada and Alaska to monitor Soviet forces. Ensuing strategic reliance on missile and nuclear technologies led to deterrence theory based on a doctrine of Mutually Assured Destruction and a multitude of contrasting schemes of

⁶³ Gupta (1995), p.120

⁶⁴ Dolman (2002), p.31

⁶⁵ Ibid., p.45

logic that are now being newly scrutinized against the backdrop of national missile defence programs and the potential for weapons to be placed into outer space.

While geopolitical thinking has traditionally concerned itself with the relationship between terrestrial geographic features and military strategies, the field has now expanded to include studies of outer space and its technology. Everett Dolman (2002) bridged the field of classical geopolitical theory to the domain of space with *Astropolitik*, a realist view that conceptualizes outer space as an environment for political and military power enhancement. The future of space technologies have even been seen by some defence strategists as all but eliminating the traditional geographic situational importance of states in contributing to security.⁶⁶ But humans are land creatures, and wars are won or lost on land, immediately suggesting that space and its technology would only represent a “strategic enabler for the prosecution of war on land”⁶⁷ rather than a new theatre of war itself. Despite a wide range of current debates on the role of outer space in military affairs, it is clear that space commerce will place economic arguments at the center of a geopolitical debate between the preservation of space as a peaceful commons, or its further ‘securitization’ by groups pursuing economic, military or other strategic goals.

As summarized earlier, outer space development in the 1950’s and 60’s provided a territorial context for the Cold War rivalry between East and West, but it also enabled an unprecedented level of industrial and social development on Earth. The level of development witnessed in space technologies has certainly kept pace with other industrial sectors and in many cases is responsible for the pace and breadth of economic globalization that has fundamentally impacted the quality of life for populations in developed and developing countries. Technology that enhances knowledge

⁶⁶ Godefroy (2000) no pagination

⁶⁷ Fergusson (2000), p.45

of resource development opportunities or increases chokeholds over aspects of the information and resource economies is another expression of geography as strategy, with the environment as an increasingly important stakeholder.

In addition to the near-Earth environment, the atmosphere and space beyond the Earth's surface represents a unique area of geopolitical importance in how it can provide access to power.

Satellite communication and observation technologies can provide certain ideological or cognitive perspectives to be gained of the vast geography of Earth. Control over certain Earth-orbits and the information provided by satellites can confer great power for political, economic and environmental decision-making.

Realist theorists of international relations have produced such notions as “space power” and “space control”, where a nation-state worldview is prejudiced over global perspectives. In these space-based geo-strategies, state competition for Earth-based resources is enhanced by minimizing the dominance of other actors. States that have developed an indigenous capacity for all aspects of space development are few, representing a realm where geo-strategic advantage can be maximized. Most space-faring states are involved in some form of international cooperative effort or in a specific niche area due to the long-term investment and research required for space missions. Some states acquire capacities and capabilities from other states, or procure only the products and services they need from the space activities of others. Space control is therefore the prerogative of only a few actors, although all states or private-sector ventures in space are affected. Where these theories and strategies for asserting control in space become important to commercial remote sensing initiatives, is where military policies are developed and justified in the context of protecting economic interests that are linked to private-sector space development. This close

association of military interests and economic imperatives also supports widely uneven development, as either economic or military hegemonies can further lead to uneven development and the inequitable securing of resources.

Whereas overt military use of space to assure state hegemony is seen as outwardly aggressive, commercial investment and societal reliance on space technologies provides impetus for space control strategies on the grounds that economic interests must be protected. In one recent articulation of the security implications of commercial space technologies, Thomas Moorman Jr. urged the US to pursue new military space initiatives, stating that “as more commerce is placed in orbit and as we depend more on space, [the Department of Defence] will need a more comprehensive program to protect our assets.”⁶⁸ Suggestions that international consortia of private-sector commercial space activities might be beyond the control of states – slowly and subtly eroding the notion of state-sovereignty by their ability to capture and transmit global information and geospatial data to anyone, anywhere – ignore the fact that certain state interests are still being served through private-sector initiatives. Crucial to this debate is the recognition that civilian EO applications represent only a small fraction of the overall use of satellites for military purposes. If commercial markets for EO were truly global in nature and based on providing ‘common good’ needs to a maximum number of participants, benefits from remote sensing and related technologies would be globalized, circumventing any need for individual state or private-sector actors to pursue geo-strategies such as space power and control, and enabling secure, regulated space development for forms of global governance.

However, as Dolman suggests in *Astropolitik*, “in formulations of state strategy, it would be disingenuous and even reckless to try to deny the continued pre-eminence of the terrestrial state

⁶⁸ Moorman (1999), p.12

and the place of military action in the short history and near future of space operations.” Dolman further claims that even when states publicly denounce the use of violence and force in space operations, “all space-faring states today have military missions, goals, and contingency space-operations plans” that pervade the ideal of true cooperation and political unity in space.⁶⁹ History reveals the political importance of technology’s advancement for establishing transportation corridors, constructing resource-based technologies such as trans-continental oil-pipelines, and for controlling key geographical regions by use of technology on land, sea and air. Technological advancement as geopolitical strategy has also resulted in the dominance by certain actors in the space technology sector. This dominance can perhaps be tempered by reinforcing existing norms and institutions that require powerful groups to share access to the commons and by placing the technological choke-points formed by modern society’s reliance upon satellite navigation, telecommunications, and Earth observation under commons-based control schemes.

If space technologies are eliminating the traditional geographic situational importance of states in contributing to security, then the territorial formulation of security may also undergo a transformation along the lines being witnessed in the transfer of commercial forms of sovereignty from the state to the corporate realm. While the notion of ‘security’ has been widely debated in the academic and popular literature over the past decade, the outcome of a critical debate on the future uses of space and its technology may strongly define what it is that we seek to secure through the use of space and EO. For the US military, its stated goal of attaining ‘full spectrum dominance’ requires that it maintain a chokehold over the space technology sector. For environment and sustainable development planners, it is imperative that the ‘commons’ aspect of

⁶⁹ Dolman (2002), p.2

space allow for the increased use of satellite sensors and Earth orbits to locate, describe and monitor the ecological and humanitarian issues that most urgently need to be addressed.

Many principles within the field of physical geography are also implied in the geopolitical considerations described above. Geophysical properties of the Earth act as strong determinants of commercial space development in such aspects as the location of launch facilities and the access and availability of valuable Earth orbits. While a discussion of orbital mechanics is beyond the scope of this study, it is significant to note that due to the eastward spin of the Earth and the variance in gravitational forces on the Earth's surface, certain very specific Earth locations are better suited as launch sites for obtaining certain orbits. In addition to Earth's geophysical characteristics that limit launch possibilities, economics plays a significant role due to fuel costs, lift power required to overcome gravity and the available payload capacity for a given launch vehicle.⁷⁰ Options for locating ground stations are also significantly limited by geographical, political and economic factors. Depending on the intended application of a space asset, certain orbits and ground locations may be desired but not directly accessible by a given state. To achieve its goals in space, a state may therefore need to engage in cooperative arrangements, exchanging launch capacities for ground station access, sharing space resources or engaging in multi-stakeholder space development projects.

Of notable value for its provision of near total global observation and communications potential is the geostationary orbit, where objects can rotate at the same speed as Earth, at a distance of 36,000 km from the Earth's surface along the equatorial plane. Satellites in geostationary orbit appear fixed relative to a point on Earth, making tracking easier since the receiving station can be fixed in place. Just three satellites placed in geostationary orbit with only three ground control

⁷⁰ *fuel includes launch plus any requirements to relocate or correct the position of space assets in orbit*

stations can monitor the entire planet between 70° north and south latitudes. The geostationary belt's uniqueness and extreme value for global monitoring has caused it to be seen as "a scarce and precious international natural resource."⁷¹ While outer space is seemingly endless, the number of satellites that can be placed in geostationary orbit is limited due to the possibility of interference from adjacent platforms. This strategic quality of the geostationary belt resulted in historic territorial claims by nine equatorial states that their sovereignty extended directly upward to geostationary altitude.⁷²

The equator is also the most efficient location for launching space vehicles to geostationary orbit as the tangential velocity of the Earth's surface is maximized at the equator, in turn maximizing launch momentum, fuel efficiency and payload capacity.⁷³ The seemingly arbitrary strategic location of geostationary orbit is of course precisely caused by the geophysical qualities of the planet Earth, demonstrating again that the possibilities for human exploitation of space is linked intrinsically to conditions on the ground.

Obtaining other orbits such as low-earth orbit, polar orbit or sun-synchronized orbit also requires a consideration of the geophysical dimensions of the Earth. Of particular concern to Earth imaging satellites is the capacity to obtain global coverage within a short period of time. Low-Earth orbits provide maximum resolution for imaging satellites but require a greater number of ground control stations. As no one state has sovereign territory extending right around the globe, many cooperative agreements are in place to enable satellite monitoring on non-sovereign territory. The US for example maintains deep-space tracking stations in Australia and Spain (among others),

⁷¹ Dolman (2002), p.74

⁷² In the 1977 Bogota Declaration, nine equatorial states claimed that the geostationary belt is the sovereign territory of those states directly beneath it.

⁷³ In a real-world example, a rocket launched due east from Kourou, French Guiane receives a 17% fuel efficiency advantage over a similar rocket launched from Cape Canaveral, USA.

while Russia maintains a fleet of space-tracking and control ships in international waters.⁷⁴ Many countries also cooperate through information-sharing arrangements and the design of space-based monitoring requirements due to their geographic proximity. US and Canadian remote sensing development was very much influenced by the proximity and shared interests of each country and the ability to share development costs, data and expertise.

The polar, sun-synchronized orbit is another key resource for military reconnaissance and weather imaging, obtained most efficiently through a launch directed due north or south. A polar-orbiting satellite placed in a slightly retrograde motion will allow the satellite to image the entire Earth as it is illuminated by sunlight. While a sun-lit Earth may not be important for radar remote sensing satellites such as Canada's RADARSAT platform, the global coverage is still important and the solar power provides for much of the satellite's energy requirements. From the discussion thus far, it can be seen that facilities that provide launch capacity either due north or south and due east along the equator become strategically advantageous. Facilities closely fitting these criteria are limited but include an Australian site, French and Brazilian sites in South America and an Italian facility based in Africa.

One further geo-strategic consideration for launching satellites concerns the fact that all but two Earth orbits require satellites to expend fuel resources to correct for small, natural but not insignificant perturbations caused by gravitational effects. These two uniquely stable Earth orbits are inclined at 63.4° and 116.6° relative to the equatorial plane, requiring launch locations at 63.4° north or south latitude. Satellites launched due east from a facility at either of these latitudes will efficiently enter a very stable orbit with minimum fuel expenditure, greatly increasing their useful lifetimes. Currently, although Alaska, northern Canada and Greenland are also ideally suited,

⁷⁴ Dolman (2002), p.81

only one such facility exists at exactly 63.4° north latitude at Plesetsk in the Russian Federation. The geographical and geophysical conditions that make this site an ideal launch facility for many groups has historically partnered Russia's scientific and technical community with numerous space agencies from around the world.

The examples provided suggest that the enterprise of space development and global Earth monitoring in particular involves many continents, nations and territories for both sharing of infrastructure and information. Global cooperation is therefore necessitated by geophysical and geographical conditions that otherwise restrict the efficient conduct of space development activities. The traditional geographic situational importance of states may be in decline, but the enterprise of space development and EO is still heavily influenced by geopolitical and geophysical realities.

3.8 Sovereignty and Security in the Global Commons

At the core of international environmental politics is a debate over the adequacy of a Westphalian system of governance to enable decision-making that addresses trans-national problems such as global environmental change or sustainable development concerns. While a familiar thesis is that ecological holism and territorial autonomy are mutually exclusive concepts, the modern state is also considered to be the only body possessing sufficient authority, resources and territorial control to enforce environmental treaties and norms.⁷⁵ Due to the international norms and treaties that recognize outer space as a 'global commons', and the ability of space technologies to inform on environmental and human conditions at any point on Earth, satellite remote sensing technologies may present unique tools for reconfiguring our political understanding of space and sovereignty in the context of environment and development decision-making.

⁷⁵ Litfin (1997) p.168

For this study, ‘sovereignty’ is understood to be a concept closely linked to the ability of states to protect their national interests through measures of control, structures largely embedded in national laws and government policies. To be ‘sovereign’ also means that a governing body is autonomous and recognized as legitimate by the citizenry. The traditional Westphalian system of governance is based upon international relations between sovereign states that alone establish regimes of authority to govern over their defined geographical territory and citizenry. Sovereign territory, as commonly defined by international treaties and spatially demarcated on maps, theoretically and practically extends from some point below ground level to the altitude of commercial aircraft flight. Non-sovereign territory or ‘internationalized’ spaces exists where no specific territorial claims have been pursued successfully, and treaties have been established to govern shared use. Examples include the major oceans, international airspace and Antarctica. Due to practical difficulties in determining the limits of territory over states, sovereignty does not practically extend to the lowest orbits of spacecraft, although various sovereignty claims have been made to geosynchronous orbits.⁷⁶ International norms and treaties have nevertheless established outer space as non-sovereign territory and satellite-based EO technologies therefore inherently collect information from beyond a traditional system of territorial governance.

In an increasingly interconnected world evidenced by global trade and mass communication, states perceive a host of emerging external threats to their sovereignty that are both military and non-military in nature. In addition, changes within states such as the transformation of the market economy, the rising power and influence of corporations, and the formation of civil society groups are all exerting pressure on the traditional role of the state. A body of research from the past decade suggests that instead of sovereignty being ‘threatened’, the notion of sovereignty has

⁷⁶ Kish, (1973) p. 44

been evolving, placing different kinds of responsibilities on states as they now interact in a theoretical 'global village'. Traditional centers of political authority are increasingly fragmented and de-centered by processes of globalization. A need for environment and development concerns to be addressed holistically also places new responsibilities on state actors whose authority and legitimacy is required to produce strategies that address these issues.

As one of the formative aspects of the sovereign state system of governance, states have carried out a responsibility to protect the citizenry and provide for their 'security'. Due in part to the shifting notion of sovereignty from external and internal pressures, and the claims by many academics and policy-makers that Westphalian governance is inadequate for addressing global problems, the concept of 'security' has itself undergone a reformulation to include various economic, human and environmental dimensions that transcend the territorial boundaries of the state.⁷⁷ EO technology orbits in this sphere of academic debate in part because satellites have enabled much of the communication that has 'globalized' politics and economics, particularly through the use of visual geospatial information, and also in the way space technologies are simultaneously pursued by states for the power they confer and the information they provide to address new sovereignty challenges. Ronald Diebert (1999) has shown that "control over these technologies has proven to be an important source of social power."⁷⁸ The role that Earth observation has played in broadly reshaping perceptions of *territory*, *environment* and *security* should not be overstated, but as a tool for re-conceptualizing traditional territorial landscapes, EO technology has enabled many groups to pursue competing goals ranging from natural resource

⁷⁷ for some examples, see Homer-Dixon (1999); Deudney et al. (1999); Matthew (1999, 2000, 2002); Axworthy (2001, 2003); Hampson (2002); Dalby (2000, 2002a, 2002b); Sadako et al. (2003); UNDP (2003); Department of Foreign Affairs Canada (2004).

⁷⁸ Diebert (1999), p.267

exploitation, territorial sovereignty and establishing cooperative international regimes to address global environmental problems.

Besides informing state militaries about territorial matters, EO technology has assisted in the reformulation of the concepts of sovereignty and security in enabling the kind of visual thinking that pervades the bounded political world of the state system of governance. Trans-boundary environmental and development concerns are growingly discussed as ‘global’ problems facing a common humanity, and ‘sovereignty’ is a concept that no longer has to be specifically linked to territory. On the other hand, as Ken Conca (1993) has argued, security metaphors can “shape and limit how we conceive of problems and solutions” and by so doing, might “privilege the role of military institutions in policy responses.”⁷⁹

Litfin (1998) and Dehqanzada et al. (2000) have argued that an emerging inability for states, particularly the US, to maintain monopolies over geospatial data collected from commercial remote sensing satellites may improve the opportunities for cooperation between states, a kind of cooperation characterized by increased global transparency, trust, cooperative gain, knowledge and the furthering of trans-national societal relations. The contrary argument and the position of some defence and security policymakers in Canada and the US is that the use of EO technology by anyone who has the economic means to purchase and use it may pose a direct challenge to the operational security of the state and to the long-term epistemological dominance of official policymakers.⁸⁰ Such analyses have initiated and resulted in the development of strong ‘access control’ policies for imagery and geospatial data, particularly by states concerned about the diffusion of social power resulting from global access to information technologies. A

⁷⁹ Conca, Ken (1993) pp.9-19

⁸⁰ Livingston et al. (2002) no pagination

predominant concern of environmentalists over the past decade has therefore been the encroachment of the military into environmental issues and the merging of existing civilian satellite programs with the mandates of intelligence and defence agencies. Earlier fears that military liberalization would see civilian EO programs come under the full control of defence and intelligence agencies have not been substantiated, but the reformulation of ‘security’ concerns and the increased reliance by defence agencies on private satellite operators for their communications, imagery and data have helped to shape policies governing the commercial EO sector.

Instead of the public or scientific use of EO satellites for long-term environmental and development planning being co-opted by the military, defence and intelligence agencies have had an influence on commercial remote sensing markets and in some cases have obtained exclusive contractual arrangements with private EO satellite operators, shutting out public access to certain spatial and temporal zones. Strong access control policies in the US may symbolize the military’s historical pre-occupation with surveillance and information denial to adversaries but its concern over the commercial and territorial aspects of remote sensing and space technology have continually guarded the most advanced technology and most valuable geospatial data for its own needs. Even when such technologies are provided by civilian governments for global monitoring, Harvey (1993) cautions that “control over resources of others in the name of planetary health [and] sustainability... is never too far from the surface of many Western proposals for global environmental management.”⁸¹

The registration and liability principles in space law have built on the Convention of the Law of the Sea, but have gone further in requiring nations to not only maintain a registry of objects in space, but for objects to hold the nationality of the state in which they are registered. While these

⁸¹ Harvey (1993), p.25

principles are aimed at placing responsibility on states for the operation of orbiting objects, they also suggests limitations to the use of satellite-acquired information for open public use or international governance as such platforms are ultimately controlled and connected to sovereign states and national laws and policies. If EO technologies were to be relied upon to inform on state compliance with environmental treaties for example, assurances as to the accuracy and validity of remotely-sensed data must be provided. Multilateral regulatory bodies that make use of EO technology may also appear biased if reliant on commercial space platforms controlled by a singular sovereign state. Nevertheless, there remains a logical utility in employing EO technologies for global regulation concerning any number of issues but most particularly environment and development concerns.

The Committee on Earth Observation Satellites (CEOS) and the Earth Observation International Coordination Working Group (EO-ICWG) are two important examples of international bodies that employ civilian environmental satellites that are ultimately controlled by national bodies such as the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA) or the European Space Agency (ESA). Many ambitious projects for multilateral EO projects have been proposed, but national and commercial interests have continued to act as a barrier to their implementation. Nevertheless, NASA's Earth Observing System (EOS) entails significant international participation and along with similar systems developed by Japan and ESA, progress has been made in internationalizing the environmental monitoring missions of numerous sovereign states. A particularly interesting example of EO satellites operating within the environment and security nexus is Europe and ESA's recently developed Global Monitoring for Environment and Security (GMES) project. GMES while still a regional initiative does include the participation of several multinational

consortia. GMES promises to deliver policy-relevant EO-based services to end-users in such realms as forest monitoring, water and soil protection, risk-based information services for fires and floods, urban planning, food supply monitoring, coastal zone management, ocean surveillance for oil pollution and water quality, operational ice monitoring for marine operations and climate change, and humanitarian response using maps, satellite imagery and geographic information. What makes the GMES initiative particularly promising is that it is driven by environmental policies at the national and international levels and a commitment to make the delivery of EO services sustainable through their reliability, availability and affordability.⁸²

In spite of the continued control of EO systems by individual states and private actors, a conceptual bridge does clearly exist between the commons of outer space and the commons of the global environment. The ‘commons’ is a concept often discussed in terms of global governance of the environment, as the protection of the ozone layer, addressing climate change or protecting biodiversity are seen as issues of concern to the planet and the human species in particular. Defined as the geographic space of the Earth and its surroundings that is not owned or controlled by one entity, the “global commons” amounts to 70% of the Earth’s surface including Antarctica. The atmosphere is also included, and to the extent that humans have explored it and found no prior claims to ownership, outer space is an integral part of the global commons. As Edith Brown Weiss (1988) has further described,

Traditionally, only areas not subject to national jurisdiction have been considered as global commons. But from the intergenerational perspective, the planet is a ‘global commons’ shared by all generations... There is a planetary trust by which we are all bound, which gives us certain rights and obligations.⁸³

⁸² http://earth.esa.int/gmes/ESA_GSE_public_info._note_1.html [accessed June 2004]

⁸³ Weiss (1988), pp.289-291

Even though modern Western traditions center humanity as the supreme authority over the Earth, political and to a certain extent economic choices are growingly constrained by the environment and ecological disruptions, a conclusion increasingly accepted by state parties to the Intergovernmental Panel on Climate Change (IPCC).

A clear argument exists that any use of the ‘commons’ by private actors or sovereign states should in turn provide benefit to the ‘common good’. Indeed this is a requirement specified in laws and treaties governing the use of outer space. Paradoxically however, control or dominance of the ‘commons’ is a primary concern of states and military strategists. Treaties that designate certain geographic spaces as ‘common’ territory have been arguably brought into existence because no one entity could ensure control or authority – the geography is either too massive, the environment too harsh, or the difficulties too great. Outer space has great utility for states to exert sovereignty and control, but ‘public good’ needs such as environmental monitoring or communications have so far enabled outer space to be preserved as a ‘commons’. With private economic interests being increasingly pursued in space, and the merging of civilian and defence space missions in the post Cold-War era, the concept of the ‘commons’ as applied to outer space is increasingly being questioned and to a certain degree, placed under threat.

The concept of ‘ecological rescue’ – the road to curbing resource over-use, unsustainable development, and ecological degradation – pins its hopes on the capacity for society to re-think its priorities and govern itself according to ecological practices rather than the advancement of economic or otherwise territorial enterprises including nation-building. At the heart of so much of the discussion on addressing global environmental change is a sense that only a fundamental attitudinal shift – particularly amongst the developed world where the majority of resources are

consumed – is required to prioritize healthy ecosystems over economic models based on inequitable and overburdened resource throughput. Recent research pursuing these critical perspectives on politics, environment and economy also feeds into an examination of EO, as a technology that can both inform on global environment and development problems, or be used to further the knowledge and control of individual states or private corporate actors.

It can be argued that the main impediment to fundamental social change is the rigidity of an existing global political and economic order that reinforces state power based on the pursuit of national income, capacity and the forces of production. This apparatus also establishes the mould for social values and cultural norms in the West, referring here to the desire for quality of life based on the accumulation of wealth and the attainment of a level of ‘security’ commensurate with the continuance of the established pattern. In short, fundamental social change may be inconsistent with the predominant norm in the developed world that sees stability – political, economic and social – as the basis for individual wealth and security, regardless of the needs of a global community. EO is now being pursued commercially by private firms that have an economic imperative to succeed in the global marketplace. These ventures, while disseminating a potentially enabling technology for environmental governance and sustainable development on one hand, are also at the heart of a debate over whether serving the ‘global good’ can be achieved while de-regulation and economic liberalization allows the private sector to increasingly pursue traditional economic patterns of development based on competition that is not unlike the traditional competition for power and control carried out by states in the system of Westphalian governance.

Richard Matthew (2002) has argued that the ‘securitization’ of the environment has helped to pave a path to a liberalized military that has in turn focused to an increasing degree on sovereignty challenges including global environmental problems. Others such as Daniel Deudney (1992, 1999) have examined the role that linking environmental concerns to security has played in the socially-constructed discourse of new ‘trans-national security challenges’ facing states. These new challenges, represented by resource dependence, economic development and large-scale environmental problems, have enabled an increasing number of links to be established between environmental agencies and traditional security planners which traditionally have very little in common. If the traditional goals of the modern state – “to defend borders and to promote industrial development”⁸⁴ are in friction with the quest for ecological integrity, then a new formulation of sovereignty could be assigned to states and to multinational corporations that are responsible in responding to environmental or human formulations of security. Technologies such as EO could assist in providing the transparent verification and compliance mechanisms required for international law to regulate common spaces and common values, in particular the environment, human well-being and planetary stewardship. It has yet to be seen how such ventures as the European GMES will affect policy decisions and further influence the concept of state sovereignty, perhaps shifting it from nation states to commons-governance and responsibility.

As Karen Litfin (1998) has argued, the consolidation of state sovereignty during the modern era has provided the basis for economic and technological interdependence through a system of stable property rights. Litfin describes the notion of sovereignty as involving rights, capacities and responsibilities in three realms: those under a state’s jurisdiction, those under other states’ jurisdictions, and those in the commons. Sovereignty and private property rights seem to be

⁸⁴ Litfin (1998), p.195

similarly constructed notions and the urgency attached to global environment and development problems seem to be involved in a reconfiguration of both. As with treaties governing the 'commons', the vast majority of international environmental agreements have been established in the absence of a discernable hegemon. Regimes that shape the behaviour of sovereign states and possibly the activities of private actors in use of the commons may be the only link to collective environmental management and the furthering of a humanitarian discourse over those narrowly defined by states, militaries or economic interests.

Robert Keohane, Peter Haas and Marc Levy (1993) have defined regimes as, "persistent and connected sets of rules and principles that prescribe behavioural roles, constrain activity, and shape expectations."⁸⁵ For 'public good' aspects of EO to dominate in the development of a commercial EO sector, a rules-based approach must be developed by states in recognition of the internationalized spaces that these industries exploit to their own advantage. Through *sovereignty bargains* states lose some autonomy to international regimes and regulations but formal sovereignty is reinforced when states or private actors become validated as the major legitimate members of such institutions. Functional sovereignty is also enhanced because actors acquire greater problem-solving abilities.⁸⁶ In the realm of private enterprise, few regimes exist to explicitly govern the ways corporations behave in their use of the commons. What form such regimes might take will be left for later discussion, but what Keohane, Haas and Levy have shown is that regimes intended to govern environmental practices have had popular public pressure from major industrialized democracies as a key variable in their formulation.⁸⁷

⁸⁵ Keohane et al. (1993) pp.4-5

⁸⁶ Ibid., pp.415-417

⁸⁷ Ibid., p.15

While regime effectiveness must be measured in terms of actually solving problems, not just in political activity, global civil society and NGOs have become one of the driving forces in advancing international agreements respecting the environment. As previously discussed, civil society groups have become more effective in part because of modern technologies and globalization. As both a product and a determinant of the shifting concepts of political space and sovereignty, a strong civil movement may be a requirement in ensuring that ‘public goods’ are prioritized over private gains in such areas as the commercial Earth observation industry.

For EO technologies to be effective in environmental governance, a loss of individual state sovereignty might need to occur, particularly in the activities of states as they operate in the global commons (high seas, atmosphere, outer space). The benefit to states would be enhanced environmental stewardship on a planetary scale and increased global environmental security and individual human security for their citizenry. EO and related geospatial technologies have been shown to have substantial application in aiding development decision-making and improving the lives of the world’s poorest people. One of the stumbling blocks to ensuring that a commercial EO sector will pursue these applications however is that corporations and private actors have no direct beneficial relationship with increasing environmental or human security globally, or in addressing development problems where the potential for profitability is low or non-existent.

Reconceptualizing sovereignty and security using the framework of the ‘commons’ may prove useful in bridging the cognitive gap that exists between public and private spaces. Spatial technologies such as remote sensing can be used to produce new physical representations and mental maps of the Earth that can prioritize the need for stewardship of commonly shared resources and values. Bioregions can be mapped without state borders, economic maps can

identify the growing development gap between rich and poor countries, and health data can be used to relate ecological stresses to human well-being. Regulatory methods, however, must also be developed to steer the uses of such empowering technologies as EO as they enter the commercial marketplace.

One of the major problems with global governance and technology-based environmental regimes is that the information required to drive decision-making processes is limited in the regions where it is most needed. A wide variety of academic research has found that science-driven agreements tend to create dynamic regimes that require updates based on new understandings and discoveries. Often the information can be derived readily through the use of EO and other geospatial technologies, but a problem exists in that only a few states have substantial expertise in their use. This enables technologically developed states to have the strongest voice in arriving at international environmental agreements, prejudicing the developed world over the developing world. As articulated in Principle 21 of the 1972 Stockholm Declaration, people have a “fundamental right to...an environment of a quality that permits a life of dignity and well-being.” This declaration perfectly articulates the tension between a sovereign right to exploit resources under legitimate control, and a responsibility not to harm the environment. If decision-making capacities can be provided to developed and developing countries alike, then international environmental regulation supported by EO technologies can be a tool in building state capacity, regulatory measures and governance regimes. The critical question is whether market forces, the private-sector, or the narrow interests of nation states should be left to influence the use of EO technologies that have the capacity, if properly regulated, to substantially influence environmental governance of sovereign and common spaces.

3.9 Political Economy

There has been much critical assessment about the potential for the information economy to internationalize thinking about environment, development and politics and the role of modern technology in bridging gaps between rich and poor economies. Through the process of globalization, market economies are increasingly shaping the forms of competition that take place between groups, particularly in technologically advanced regions. By examining the political economy of certain key technologies, widespread social practices that rely on the advancement of technology can be seen to reinforce and reproduce global economic power structures.⁸⁸ For this reason, satellite technologies have had an important role in reproducing capital accumulation in the late 20th century, serving to promote certain values and world-views over alternatives.

As seen from the trend toward private-sector EO, governments are increasingly looking to the global market economy to generate the ideas and incentives needed to meet new challenges at every scale. Remote sensing and space technology has the ability to globalize awareness of environmental and other global problems such as humanitarian crises and weapons proliferation. Much as the telecommunications industry has globalized mass media and the Internet has globalized information, EO can help to create a new world superpower represented by the world of public opinion. Unfortunately, however, a private-sector-directed EO industry may prejudice the stockholder model of development over a stakeholder model without adequate regulation of the information commons.

Economists have long studied the concept of the military-industrial complex that enables massive production to take place during wartime and the continued viability of the supporting industrial base during peacetime. From the historical record, it is clear that satellite remote sensing

⁸⁸ Paterson (2000b), p.253

technology emerged from the military, transitioning to the civilian and now private sector. In many military planning documents of the post Cold-War era, the growing influence of liberal economic and commercialization practices that rely on efficient production and global market viability for new products can clearly be seen. Military economies have also continued to be one of the most powerful engines of technological innovation. The impacts and influences that transitions within this mutual relationship might have, particularly in affecting patterns of material consumption and in moderating development are important issues concerning commercial EO.

The digital transition and global flow of Earth information made possible by the proliferation of geospatial technologies into many branches of the world economy has been compared to the 1960 commitment by then US President Kennedy to “put a man on the Moon before the end of the decade.” Both efforts required the motivation and mobilization of large resources and cooperative industrial development. While the stated goal for some policymakers has been to pursue technological advancement to bridge gaps between rich and poor economies as a means of development, the goals for others is to maximize profitability and exploit emerging markets as a means of strengthening certain positions over others.

The globalization of telecommunications in the Information Age can be seen as making the world a conceptually smaller, interconnected sphere, ushering in advantages for business, development and the speed of decision-making. When the merits of EO are presented for global environmental governance, it implies a globality of the issues with an emphasis on the role of the information economy in formulating new views and directions of the world. Economic globalization can also be seen to have diluted the commerce aspects of state sovereignty, leaving defence agencies to strengthen their hold on one of the primary sovereign duties left to states – maintaining awareness

and capability to respond to perceived national threats. As situational awareness by military organizations relies heavily on the flow of information through and from space, subjecting control of this information flow to global market forces could potentially undermine the long-term epistemological dominance of states in characterizing or responding to threats. A political economy of space technology and information that is based increasingly on global market forces and the activities of international organizations that specialize in space services could contribute to shifting forms of sovereignty expressed not only through commercial policies but also through countries' foreign and defence policies.

David Rhind (1999) has suggested that the predominant institutional forces re-shaping the world are the actions of business and government, underpinned by new science and technology. But he critiques the commonly held perception that we are all now living in an interconnected, digital world profiting similarly from recent advances in technology. His argument is simply presented by the following consideration of the world if it were reduced to a village of 1000 people:

There would be 584 Asians, 124 Africans, 136 from the Western Hemisphere (both North and South America), 95 Eastern/Western Europeans, and 55 Russians. 520 would be female, and 480 would be male. 650 would lack a telephone at home. 500 would never have used a telephone. 335 would be illiterate. 333 would lack access to safe, clean drinking water. 330 would be children. 70 would own automobiles. Ten would have a college degree. Only one would own a computer.⁸⁹

The Geographic Information for Sustainable Development project (National Research Council, 2002) contributed to the World Summit on Sustainable Development in Johannesburg in August 2002 by summarizing the importance and applicability of geospatial technologies and data for development in sub-Saharan Africa. Some of the project's major findings were that inadequate telecommunications infrastructure, lack of training and skills, data restrictions due to costs,

⁸⁹ as quoted in Rhind (1999), p.30

standards or access, and limited private-sector demand to spur the development of new technologies, all resulted in barriers to the use of geospatial technologies for improving livelihoods. In addition, these barriers were also faced by many African countries in fulfilling international treaty obligations for environmental reporting.⁹⁰

Other important factors that limit the ability of the world economy to bridge development gaps or digital divides are based on cultural and philosophical understandings of development that subject minorities to the will of elites. Technological development may represent a post-colonial project that emphasizes the material value of resources over more transcendental values. A primarily Western belief seen by governments' drive towards privatization for certain industries is that the stronger the protection of property rights, the better it is for economic development as this protection encourages the generation of wealth. In Africa, less than 10 % of the continent's land is formally owned, with management of resources often based on a commons-system of land tenure. While the empirical economic problems of development are important, major gender imbalances, access to education, the primary use of the English language and the inherent bias of a Western world-view in the technology economies and systems that seek to address development and environmental sustainability goals must be understood.

Shifting state responsibilities towards commercial outcomes for which, in the case of EO technologies, defence organizations maintain a strong investment, has the potential to reinforce these barriers and Western world-views of what constitutes sustainable, equitable development. In the words of development critics such as Arturo Escobar (1995): "It is clear that the technological gap between rich and poor countries is growing in the wake of the global economic

⁹⁰ National Research Council (2002), p.5

restructuring of the 1980's and the advent of cyberculture.”⁹¹ As the GISD report suggests, with limited geospatial data and limited appreciation for its value, many African states face an uphill battle in addressing development concerns. Urging developing countries to make greater use of and investment into geospatial technologies inevitably supports the commercial interests of technological elites that seek new markets and a primarily Western-view of development, measured in economic terms rather than in terms of improvement to human livelihoods or environmental sustainability.

It is important then, to view the world from two theoretical perspectives when considering the growing commercialization and increasing privatization of an industry such as that of satellite remote sensing. The world is still relatively unconnected, with substantial markets (and much work) available for investors of technology aimed at making new connections. The other perspective is that only a very small fraction of the world has access or even knowledge of the kind of technologies that are nevertheless affecting the lives of billions of people every day.

The changing role of governments in the mapping and surveying business over the past several years and changes in societal attitudes toward governments have led to decentralization and privatization and an ensuing reduction in civil government capacities in the geospatial technology sector. This trend supports strengthened commercial remote sensing industries both in Canada and the US, where the roles of government institutions are evolving from *doers* to *enablers*, *facilitators* and *regulators*.⁹² With national commercial interests high on politicians' agendas and the catch-words of the day in public administration being effectiveness and efficiency of government services, the private sector is increasingly being tasked to do work previously

⁹¹ Escobar (1995), p.221

⁹² Rhind (1999), p.30

performed by governments. Commercial EO ventures, however, are based on business cases that prioritize the profit potential of sales of imagery and services instead of the provisions of goods and services needed by the public.

In the Canadian and US contexts, the political and socio-economic effects of 9/11 must also be taken into account when considering the political economy of the commercial EO industry.

While economic liberalisation and globalization may have reduced the effect of political borders on trade in many areas, 9/11 has more recently resulted in the reassertion of territorial sovereignty, particularly in the US. In Canada, while many new border security initiatives and policies have responded to 9/11, the cultural viewpoint from north of the 49th parallel is that the US – Canada border is largely a commercial control point. In the US, the same border is increasingly seen as a ‘security’ border.⁹³ While commercial sovereignty has arguably been diluted between the two major trading partners due to multilateral and international trade agreements and regimes, a return to territorial sovereignty, particularly in the US may increasingly influence commercial policies, particularly with respect to historically linked industries such as space technology development. Heightened concerns over private-sector trade in traditional dual-use technologies such as satellites and remote sensing may limit certain market possibilities unless primary ‘security’ interests are aligned between the two countries. Industries such as the geospatial sector may be effective at promoting its own interests, but security discourses may draw them deeper into a resurgent military-industrial complex that is clearly guided by the territorial sovereignty concerns of state defence and intelligence organizations.

⁹³ Daniel Drache, from an Oct.2004 discussion of his book *Borders Matter: Homeland Security and the Search for North America*, Fernwood Publishers, Toronto, March 2004.

Emphasizing a need for global trade and international cooperation in geospatial technology development and information for sustainable development and environmental governance applications may prove more influential in opening EO markets and networks over the long-term but will be increasingly difficult if territorial sovereignty concerns dominate the political economy of the commercial remote sensing industry. But territory itself is less a source of national wealth in an information economy, as industrial innovation and intellectual property become increasingly important factors in a global economy that transcends political sovereignty.

As commercial EO providers obtain the crucial information about the Earth that can be used to form various discourses on global security matters, their role in formulating public perception and influencing official policies will be increasingly important. A lack of perceived ‘public goods’ from private EO operators may heighten concerns that their profit-seeking enterprises are too reliant on the policy responses to border protection, homeland security and territorial sovereignty.

3.10 Summary

Early international norms governing outer space activities reinforced the peaceful, normative collective vision of space as a global commons. This popular vision lies in contrast to the strategic nature of space-borne technologies and the information they provide. International power status associated with having a state-capacity in space is also driving more countries into the space industry, and propelling private industries to invest as well. Discourses contrast between those that see EO commercialization as an opening up of the global commons for democracy and equal development versus those that see defence agencies widening their mandate to secure greater economic control over EO development for territorial sovereignty concerns.

Rather than opening up the global commons to all, East-West competition in space during the Cold War was on one level the embodiment of all the mistrust and fear that existed during that period. On another level, all that were aware of such developments as the race to the Moon, were given hope that beyond the stalemate of nuclear deterrence strategy and the realist logic of Mutually Assured Destruction, a universe lay just beyond their grasp, ready for discovery. As the continued societal impact of the Earthrise and Whole Earth images suggest, there is much promise for EO to contribute to a reconfiguring of the Earth and its most vulnerable ecosystems as a 'global commons'.

Satellite imagery, while conceptually simple in its final product, nonetheless requires a great deal of processing and image correction before becoming useful for analysis. Once classified into land-use types by computer algorithms and fed into decision-support systems with other geographic and land-use data, the whole process of analysis can be undertaken remotely, thousands of kilometres away in a comfortable office building for example, without any 'image analysts' actually visiting the region being classified and decided-upon. While this in itself does not pass judgement on the outcomes, it presents us with the possibility that local interests can be obscured. Geographies are transformed through EO into an exhibition or a representation, externalized from the original. The environment is similarly represented in an objectivist and empiricist way, externalizing nature and its inhabitants, to become known only through theories and intervention by external forces.⁹⁴

From the recognition that technology wielded by powerful forces can augment power due to the strategic importance of geospatial information in a knowledge-based global economy, and the detachment that such technologies and world-views can foster between humans and their

⁹⁴ Escobar (1995), p.8

environment, a perspective can be gained that the pursuit of private interests in space is not neutral and is itself involved in the social production of space, differences, subjectivities and social orders. The importance of discourse and the power of propagating visual representations in formulating understandings about the world can not be overlooked in any discussion on technology and its role in globalization.

From the above considerations, two prominent directions present themselves for the private EO sector that may largely be moderated by the role of consumers within the global information economy. These two directions operate under different purposes and world-views and are influenced by very different power structures. First, nation states are concerned with economic growth, sovereignty and the security of citizens and resources. Second, 'ecological rescue' requires the global 'securing' of the environment and sustainable human livelihoods, perhaps requiring international cooperation in Earth monitoring to protect and regulate the global commons. The balance will be largely determined in an economic arena that is currently very imbalanced. While the future remains uncertain, the global economy is predominantly powered by self-interested elites who have the ability to take advantage of existing inequalities and gaps in access to resources and knowledge. The market may also influence, and be influenced by national policies and international norms. Industry self-regulation is also a potential outcome, but each of these possible futures will be shaped by prevailing discourses on security.

4.0 RESEARCH DESIGN AND METHODOLOGY:

This chapter summarizes the methodology used to examine the various environment and security discourses reflected in the commercial Earth observation industry. This includes a theoretical assessment of the cognitive appeal of Earth imagery, a historical analysis of EO issues, applications and international cooperation, a review of marketing strategies for various private EO firms, and an examination of interlaced policies and discourses influencing developments in the commercial remote sensing sector. Additionally, a discussion of study limitations is presented.

4.1 Documentary Analysis of Prevailing EO Policies and Discourses

While there is immediate difficulty in designing research methods to predict future outcomes, part of the argument being employed in this research is that government policies and discourses concerning ‘transformational’ technologies have shaped, are shaping and will continue to shape the trajectory followed by industries seeking to develop technologies such as remote sensing satellites. The analysis of relevant government policies and prevailing discourses are therefore key elements of this research. Representative of the regulatory direction for remote sensing in Canada is Bill C-25, “*An Act governing the operation of remote sensing space systems*” formerly known in its early draft form as the *Access Control Policy for Commercial Remote Sensing Satellites*. Additionally, the *Canadian Space Policy Framework* (CSA, 1994) and the *Department of National Defence Space Policy* (DND, 1998) provides some indication of the regulatory atmosphere for the uses of space and space technology in Canada.

US policies governing commercial remote sensing are more developed, beginning with the *Land Remote Sensing Act* of 1992 and supplemented in 1994 the *Policy on Foreign Access to Remote Sensing Space Capabilities*. These policies were later superseded by the *Commercial Remote Sensing Policy Act* of April 2003. Current US Space Policy is also analysed for its overarching influence on the development of the space industry in the US.

International treaties governing the uses of outer space and EO satellites are also analysed in the historical analysis section as they represent a baseline norm for the actions of states in space development. The text of two such documents including the *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*, and the *Principles Relating to Remote Sensing of the Earth from Outer Space* were analysed as they outline the major international obligations that Canada and the US have agreed to with respect to domestic regulation of satellite operators and space activities.

Both domestic policies and international agreements have become subject to a certain degree of interpretation by governments, industry and the public, resulting in potentially divergent discourses on the appropriate uses of space technologies. The method of textual analysis used for policy documents therefore complements the theoretical discussion concerning security discourses associated with the uses of remote sensing satellites for Earth observation. Both policies and prevailing discourses are therefore discussed together as they have largely defined the applications potential and commercial viability of the commercial remote sensing industries in both Canada and the US.

4.2 Commercial / Marketing Analysis of EO Industry

A major theoretical argument developed in preceding chapters was that human visual and cognitive processes are important drivers of consumption and commercial outcomes within the global geospatial industry. This suggests that much can be learned from an assessment of the broader commercialization or marketing plans of satellite remote sensing firms. For this reason, economic data was analyzed where available, and several documents developed by commercial and civilian satellite operators for marketing purposes were chosen for analysis to include web-based information and public reports.

4.2.1 Economic Analysis

Measuring the economic impact of a global commercial EO market is a difficult and approximate task, but several major studies have been undertaken to assess the risks and potential for growth in the EO market. While a detailed economic analysis of the EO industry is beyond the scope of this study, a cursory analysis of several available market studies can provide for a further assessment of prevailing discourses and the balance between ‘common goods’ and private interests being pursued within the commercial EO industry. While civil space agencies such as CSA and NASA study space industry market trends and characteristics to provide advice and guidance to national industries, the reports commissioned by industry groups also offer a complementary source for analysis. For this reason, both government economic analyses and industry-commissioned reports were used for assessing the state of the EO sector in Canada and the US. Several recent documents published by the Canadian Space Agency were analysed including *Global Space Sector Market Trends and Drivers – Year 2002 Edition* (CSA, 2003a), *Earth and Environment: Significant Canadian Events and Achievements Report 2003* (CSA, 2003b) and *State of The Canadian Space*

Sector 2002 (CSA, 2004). For US sources, Futron (2001, 2003) produced *Trends in Space Commerce* for the Department of Commerce (DoC) and the *2001-2002 Satellite Industry Indicators Survey* for the Satellite Industry Association. Henry Hertzfeld (2002) produced *Space Economic Data* for the DoC which provides a further source for analysis. Additionally, the American Society of Photogrammetry and Remote Sensing (ASPRS, 2004) has produced the *10-Year Industry Forecast*, a multi-year survey of the remote sensing industry which provides insight into the state of the US industry.

In discussing the ‘EO sector’ of the North American space industry, it is important to define the scope of what is being measured as EO services and remote sensing products can include any number of categories including data, imagery, value-added products, GIS and technical services. For this reason, an attempt has been made to use ‘pre-value-added’ revenues paid to civil and commercial remote-sensing satellite operators for basic satellite data. Enhanced satellite data is often distributed by ‘value-added resellers’ and fees are also paid by operators of ground stations that receive satellite data, creating other sources of economic data. Depending on the economic analyses contained in various documents, one or more of the above categories will be included, but the figures will not include development, manufacturing or operating costs for satellite platforms, or revenues to government agencies that operate non-commercial platforms (i.e. meteorological satellites). This choice of economic data narrows the discussion to the purely commercial realm of satellite imagery, and enables a better categorization of applications between those judged to be serving the ‘common good’ and those serving private interests or military organisations.

For the purposes of this study it is important to provide a definition of ‘common good’ or ‘public good’ applications for EO as one of the primary variables being assessed. These applications were

considered to be those generally available for domestic and international use that were broadly used for civil security and common governance issues including environmental monitoring, transportation safety, natural disaster management, forestry and agricultural management, humanitarian aid, development planning and multilateral treaty verification. A classic economic definition of public goods as *nonrival* and *nonexcludable* goods is usefully borrowed to describe a situation where the consumption of these goods does not detract from the consumption opportunities of others, and the benefits are available to all once the good is provided.⁹⁵ A second broadly defined category of applications consisted of those contributing to national and economic security outcomes involving strictly private and sovereign state uses. This category includes applications for natural resource exploitation or for national defence and military planning needs. While this second category of use for satellite EO may also be available internationally and while military planning is also conducted to ensure civil security including responding to humanitarian crises, the applications in this category would generally be understood to be meeting the needs of one group to assure its advantage over others, therefore not pursuing a ‘common good’ outcome.

4.2.2 Commercial Marketing Analysis

In Canada, the RADARSAT satellite program is the pre-eminent remote sensing platform that is currently undergoing privatization and commercialization. While the current RADARSAT satellite is operated by the Canadian Space Agency (CSA) in partnership with the Canada Centre for Remote Sensing (CCRS), imagery and geospatial data applications are marketed by *Radarsat International* (RSI), a private-sector company owned by MacDonald Dettwiler and Associates (MDA). For RADARSAT-2, the follow-on platform planned for deployment in late 2005, RSI and MDA will have exclusive commercial rights to data and will be the private operator of the satellite.

⁹⁵ Cornes, Richard and Todd Sandler (1986). *The theory of externalities, public goods, and club goods*. New York: Cambridge University Press, p.6

Due to the current transition of the RADARSAT program from the public and semi-commercial realm to the fully private and commercial realm, descriptive program documents were analysed from each of CSA, CCRS, RSI, and MDA. Commercialization plans, product application descriptions and websites were all assessed utilizing a documentary analysis that attempts to describe the collective message conveyed by text and imagery.

A similar approach was used to assess the driving market presence of a number of private US firms, including Space Imaging which operates the IKONOS-2 satellite, DigitalGlobe which markets imagery from its QuickBird-2 platform and OrbImage which manages commercial operations for its OrbView remote sensing satellites. Wherever possible, the program thrusts of each of these satellite operators will be highlighted. Each operator is bound by domestic laws and international norms but they vary widely in their marketing approaches, offering a useful array of public information to be used in this analysis.

4.2.3 Informal Interviews with Commercial Remote Sensing Practitioners

The outcomes of informal discussions with several key users and marketing specialists within the remote sensing community were used to supplement the textual analysis of commercial documents describing operating missions and applications development priorities. The remote sensing ‘community’ was defined for this purpose as a loose grouping of individuals who derive personal income from the use of commercially-available satellite remote sensing technology. From these discussions and the author’s participation in a number of technical seminars and short-courses on the use and application of commercial remote sensing imagery and products, a general range of conversations took place about environment and security themes and the potential for remote sensing to influence and inform human thinking on environment, development and security issues.

The purpose of including a series of discussions with various individuals from the remote sensing community in the design of this research was to gain a wider appreciation of how this community of reference thinks about access to Earth imagery as a public or private good. In addition, an appreciation was gained about how such industries self-govern and how remote sensing policies and applications might shape and be shaped by this community in the future.

4.3 Historical Analysis

In conjunction with the above data, textual and documentary analyses, a historical overview of the emergence of space industries and satellite remote sensing in particular for both Canada and the US is undertaken. By examining the development of applications for remote sensing and EO from the first human entry into space to the present, a context for comparison is provided between the Canadian and US commercial geospatial industries. In addition, various significant international cooperative efforts relating to space development and satellite remote sensing can be seen to have had an influence in the directions that both EO industries have taken. Examining the development of EO policies and industries from a historical perspective also provides a context for understanding why certain outcomes may be more likely than others in terms of future applications development and regulation.

Due to the overall human fascination with outer space developments and the well-established civilian space agencies in both Canada and the US, detailed histories of each country's civilian space activities are widely available. NASA and NOAA sources were predominantly relied upon for the US historical survey, while the Canadian perspective was summarized from records largely made available by CCRS and the CSA.

4.4 Study Limitations

Due to the relative youth of the commercial remote sensing industry, long-term trends analysis using reliable economic data is not possible. Furthermore, detailed data is often considered ‘commercial proprietary’ and is not generally available to the public despite the current high levels of public funds used to support these commercial ventures.

While it would be revealing to ascertain the precise breakdown in commercial satellite imagery sales for a variety of categories including domestic and international, military and civilian, environmental protection and resource development, the definitions used for these categories are critical to the statistics generated. Availability of well-defined categories will be a limitation of any study attempting to divide ‘public good’ applications from privately-motivated or military applications. Indeed, how the public or ‘common good’ applications are defined is a matter of much debate and is as contestable as the use of ‘security’ in both a military and environmental or human context. Defence needs for imagery may range from map production for natural disaster response or for identifying targets. Civilian imagery in the realm of environment and development may be used for protecting sensitive ecosystems from industrial development, or for geographically identifying resource claims to enable their economic exploitation.

Although several studies commissioned by space agencies and satellite industry groups have attempted to map-out the course that a commercial geospatial industry might follow over the coming years, data is often predictive and grouped according to industry sectors that don’t easily translate into the two predominant areas of concern to this study, namely environment/sustainable development and defence/sovereignty/private economic gain. Use of data provided by these studies limits this research to the methodologies employed therein, but quantitative analysis of this data is

only a small aspect of this research which is looking at overall trends, policy challenges and theoretical considerations regarding public and private needs. To augment the publicly available data and the combined research and economic trends available in published reports, individual discussions and interviews with marketing representatives and experts within the commercial remote sensing industry have provided a balanced approach.

As the commercial remote sensing ventures analysed in this research differ in terms of the Earth imaging technology being used on satellites, a methodological inconsistency might be suggested when comparing various firms. While the RADARSAT sensor utilizes Synthetic Aperture Radar (SAR) instead of optical imagery, each EO firm is a partner in marketing various types of imagery, often claiming that the integration of multiple sources of data provides more detailed information than one sensor alone. As all data ultimately presents Earth images there is no general inconsistency in comparing SAR applications with optical and/or multispectral (colour plus near infrared) remote sensing platforms. An additional limitation of this study is the focus on satellite remote sensing to the exclusion of aerial remote sensing, justified by the focus of this research on globally scaled issues such as outer space development and governance of the commons.

Some limitation is recognized in the informal interviews conducted with members of the remote sensing community, the first being due to geographic considerations as Canadian experts and remote sensing professionals were generally accessed. A second limitation is based on the economic, class, education and gender factors inherent in the group of individuals accessed for discussions. The remote sensing community is largely male, associated with the middle to upper economic class and generally very well educated and technologically aware, therefore much more likely to see technology as providing an adequate approach for addressing certain global problems.

While the context-dependent nature of informal discussions conducted with the remote sensing community does not provide a rigorous set of data to test hypotheses, efforts were made to engage as diverse a group of users and followers of remote sensing technology as possible. In terms of the historical analysis conducted in this study, the most accessible public records of space development undoubtedly prejudice the successes over the failures. This limitation is assumed to be relatively equal in both Canadian and US historical perspectives.

5.0 ANALYSIS

5.1 Historical Analysis of Earth Observation

To understand the current challenges presented by private-sector commercial remote sensing in Canada and the US, it is useful to trace the historical developments that helped to shape the industries and policies in each country. What follows is the telling of two inter-related stories of remote sensing development that helped to form the current directions for this industry and initiated certain broad policy approaches including how ‘public good’ applications for environment and development have been balanced with other competing priorities.

5.1.1 Part I – The Early Years of Space Science and International Space Policy

The practical appeal of airborne observation has a long history, with hilltop viewing providing humans with an ancient means of understanding their surrounding landscape. Hot-air balloons were developed as much for this purpose as for transportation. The advent of photography soon found a union with airborne flight, recognized as both strategic and exploratory, providing new knowledge of the Earth’s geography. The Chicago Convention on International Civil Aviation, signed in 1944, included a requirement for states wishing to acquire air photography of another country to first get permission. Article 36 of this agreement provides that each state “may prohibit or regulate the use of photographic apparatus in aircraft over its territory.”⁹⁶ Despite this, US concerns over missile installations in the Soviet Union in the 1950’s saw numerous high-altitude over-flights of Soviet territory by U2 aircraft. While the photography obtained was useful to

⁹⁶ Convention on International Civil Aviation, signed at Chicago, Dec. 7, 1944 (Chicago Convention)

military planners, the U2 was vulnerable. Based largely on territorial sovereignty limiting airborne observation, the concept of an 'Open Skies' treaty was proposed in 1955 as a means by which the US and Soviet Union could monitor each other's arsenals and military activities. Rejected by the Soviets as a clumsy US attempt to legitimate espionage, and particularly following the shooting-down of a U2 aircraft by the Soviets, the Central Intelligence Agency (CIA) and the US Air Force concentrated efforts on developing satellites for spying from the non-sovereign domain of outer space, a development that performed a similar function to 'Open Skies' but with the polarizing effect of creating a wide strategic divide between those countries possessing access to this form of information and those that did not.⁹⁷

In the civilian realm, studies of remote sensing for geology, hydrology, cartography and meteorology were being undertaken in the US and Canada as a result of the recognized mapping potential of early airborne photography. With the successful launch of the world's first satellites, remote sensing practitioners immediately recognized the potential for observing the Earth from space for both military and civilian purposes. Commercially, space-based communications ventures gave the initial impetus for private-sector involvement in the space-race, and it would be several years later before civilian governments began to look seriously at deploying satellites for environmental or resource management purposes.

Due to the growing recognition that satellite technology could provide powerful information on a global basis, international bodies such as the United Nations became engaged in debates over how to guide the new space technology in a direction of peaceful development. During 1958-59, in the year following the Soviet launch of Sputnik, the UN established the *Committee on the Peaceful Uses of Outer Space* (COPUOS), tasked with coordinating peaceful international cooperation,

⁹⁷ Haines (1997) and www.dfait-maeci.gc.ca/arms/european4-en.asp [Oct.15, 2004]

encouraging continued research among members, disseminating information on outer space matters, and studying legal problems arising from the exploration of outer space.⁹⁸

In the US, the *National Aeronautics and Space Act* created the National Aeronautics and Space Administration (NASA) and established policy to devote US civilian space development to “peaceful purposes for the benefit of all mankind.” At the same time however, this formative legislation explicitly established in law and policy a separate and independent military space program under the responsibility of the Department of Defence (DoD).⁹⁹ By 1960, the two streams of satellite development in the US (military and civilian/scientific) had proven the capability of sensors to capture and transmit imagery and meteorological data to surface ground stations, but it had proven difficult to successfully launch and orbit Earth monitoring satellites with as many failures as successes in the early days. Initial civilian efforts concentrated on one of the most obvious phenomena to study – the weather – with the very first television picture from space transmitted on April 1, 1960 by the TIROS-1 satellite.

While political rivalries delayed any significant progress toward setting principles for the development and use of outer space within the new COPUOUS, the UN received an address from US President Kennedy in 1961, which provided a rousing call for international cooperation in space. During the very same year, the National Reconnaissance Office (NRO) was being established in the US to coordinate its space-based military surveillance program, indicating the dual-track approach of the US government. Kennedy’s speech actually proposed that the UN charter be expanded beyond the terrestrial sphere to include the entire universe. This striking proposal became a key element to many future multilateral efforts in space, enabling the

⁹⁸ United Nations (1959) text of UN Resolution 1472

⁹⁹ *National Aeronautics and Space Act*, Public Law 85-568, sec.102(6), 29 July 1958

negotiation, within COPUOS, of a resolution stating that the realm of international law included outer space and the celestial bodies, and that the exploration and use of space was free and open to all nations.¹⁰⁰ A registry for all space launches was established, an international cooperative agreement on space-based weather monitoring and communications was signed, and COPUOS received an increasingly expanded membership, remaining one of the largest committees in the UN system.¹⁰¹

In 1963 the UN declared its *Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space* which was instrumental in the formulation of future treaty instruments and national policies respecting the civilian development and use of space. Of particular significance was the third principle of this declaration that stated: “Outer space and celestial bodies are not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means.”¹⁰²

Besides the Soviet Union and the US, Canada also had a satellite in orbit by the early 1960's, designed and constructed by the Defence Research Telecommunications Establishment to study the ionosphere and aurora borealis. Defence research in Canada was vitally important at that time as it became a major contributor of funding to universities either through scholarships, grants, fellowships or contracts. It also became a powerful instrument of industrial development. The activities of the Defence Research Board (DRB) peaked in 1957 with a budget of almost CAD \$70 million (in 1957 dollars). This was equivalent to 4.5% of the total defence budget of CAD \$1.6 billion which itself represented 6.6% of Canadian GDP

¹⁰⁰ United Nations (1961) text of UN Resolution 1721

¹⁰¹ United Nations / COPUOS <http://www.oosa.unvienna.org/COPUOS/membership.htm> [accessed May 17, 2004]

¹⁰² United Nations (1963) UN Resolution 1962 (XVIII)

at the time.¹⁰³ By comparison, defence spending in the US was \$45 billion in 1957, a level 28 times greater than in Canada and representing 10% of US GDP.¹⁰⁴ The DRB had a total staff of 2600 with 630 scientists and engineers working in 26 fields, spread among 11 establishments, on 190 active projects. Besides the Avro Arrow aircraft, another major outcome of early DRB-related work was infrared aerial remote sensing of floating ice in the Canadian Arctic, designed to monitor unauthorized passage of foreign vessels through the North-West Passage and to provide information for safe surface navigation.¹⁰⁵

While the military applications of satellites were already far advanced in the US, civilian uses of Earth observation (EO) were emerging. As noted earlier, the Environmental Research Institute of Ann Arbor held an unclassified international symposium on remote sensing in 1963, marking a debut of mainstream civilian remote sensing industries in both Canada and the US, and linking at once these two main participants in their technological and scientific mission to pursue civilian atmospheric and Earth monitoring.

The US Nimbus satellites, first launched in 1964, carried a number of instruments including microwave radiometers, atmospheric sounders, ozone sensors, the Coastal Zone Color Scanner, and an infrared radiometer. It became obvious to the few government officials in Canada that were interested in airborne remote sensing at the time that the technology being advanced in the US could become useful in managing natural resources and environment, especially because of

¹⁰³ Adapted from J.L.C Carrier (2003) *Defence Research: A Versatile 'Helix' of the National System of Innovation*. p.13 available at <http://198.231.69.12/papers/nssc5/carrier.doc> [10 November 2004] and from Bill Robinson and Peter Ibbott (2003) *Canadian military spending: how does the current level compare to historical levels?* Project Ploughshares Working Paper 03-1, pp.7-11; note: Canadian military spending of 6.6% GDP in 1957 is historically high when corrected for currency values, influenced also by steadily increasing GDP figures.

¹⁰⁴ The White House (2004) *Historical Tables: Budget of the United States Government Fiscal Year 2005*. p.46 available at www.whitehouse.gov/omb/budget/fy2005/pdf/hist.pdf [10 November 2004]

¹⁰⁵ Canadian Centre for Remote Sensing, "Remote Sensing Then and Now-Early Beginnings 1960-66", NRCan. http://www.ccrs.nrcan.gc.ca/ccrs/org/history/history1_e.html [12 March 2003]

Canada's vast and relatively inaccessible land and continental shelf territories. Canadian officials obtained some access to US technology to carry out civilian aerial remote sensing experiments and began thinking of ways to promote remote sensing in the government sector.¹⁰⁶

In the meantime, US programs were progressing with NASA's initiation of the Earth Resources Survey Program in 1965 to develop methods for remote sensing of Earth resources from space which included the participation of the US Department of Agriculture and in 1966, the Department of Commerce. The 1966 initiation of the Environmental Science Services Administration (ESSA) Satellite Program in the US was tasked with providing cloud-cover photography to the American National Meteorological Center. Over its brief four-year lifespan, ESSA satellites transmitted thousands of images, enabling over 300 receiving stations and 45 countries (including Canada) to access images for weather prediction.

Following the lead of the US in establishing NASA and early remote sensing programs, a recommendation was made in Canada in to establish a Canadian civilian space agency.¹⁰⁷ Recommendations were similarly made at the working level to create a government-wide agency in Canada to oversee remote sensing. Disagreement over jurisdiction and purpose for the programs led to inaction on both recommendations while the US had by the same time established three major government sectors with interests in remote sensing from space. Whereas the US pursued separate uses for remote sensing technology in the defence, intelligence and civilian sectors, Canadian government officials pursued remote sensing research under a somewhat

¹⁰⁶ Canadian Centre for Remote Sensing, "Remote Sensing Then and Now-Early Beginnings 1960-66", NRCan. http://www.ccrs.nrcan.gc.ca/ccrs/org/history/history1_e.html [12 March 2003]

¹⁰⁷ In 1967, John Chapman was the senior author of a report entitled "Upper Atmosphere and Space Programs in Canada", an extremely influential report now known as "The Chapman Report". In this paper, Chapman recommended that a Canadian space program move beyond space science to pursue the development of Canadian satellites tasked with addressing communications and resource management challenges caused by Canada's vast territory.

diffuse but singular civilian umbrella. Indications of a much lower risk tolerance within the Canadian government for investing in new technologies were already being seen by this point, and remote sensing may have been even later emerging in Canada if not for the flexibility afforded to scientific research and development programs at the Geological Survey of Canada at the time. NASA's civilian remote sensing program had emerged independently from the military and intelligence programs, a relationship that continued separately for several decades, with each agency pursuing distinctly different missions. In Canada, a joint approach was pursued, often with cross-collaboration between the civilian and defence sectors.

A 1966 US proposal to develop an Earth Resources Observation Satellite was welcome news to remote sensing scientists in Canada that had received, in principle, a data-sharing agreement with NASA. However, the US project was replaced with a revised proposal in 1969 to develop an Earth Resources Technology Satellite (ERTS), an experimental platform later to become the civilian Landsat program. Reaching agreement on data-sharing proved more difficult with ERTS, and initial Canadian efforts to receive data from this satellite at a potential Canadian ground station were rebuffed by NASA officials who suggested, "...it would be foolish [for Canada] to invest in a readout and ground data handling facility as it would be too large a risk." NASA's argument against allowing Canada to receive data directly from its satellite consisted of the high cost for Canada of building its own ground station and a claim that the Canadian landmass could be covered from three readout stations in Alaska, Arizona and New Jersey, coupled with the use of an on-board tape recorder that could record data beyond the range of the three stations.¹⁰⁸

¹⁰⁸ Canadian Centre for Remote Sensing, "Remote Sensing Then and Now-Early Beginnings 1960-66", NRCan. http://www.ccrs.nrcan.gc.ca/ccrs/org/history/history1_e.html [12 March 2003]

Both Canada and the US had strong traditions of keeping the control of aerial photography and mapping within their boundaries, consistent with the Chicago Convention. Canada's appeal to the US for access to its satellite data was based on this international agreement which although designed to respond to sovereignty claims over airspace, had some applicability to outer space in the absence of any other international norm for satellites. The need for policy respecting the use of civilian remote sensing satellites therefore created a precedent setting situation, stemming from the fact that countries did not want to purchase imagery of their own territory from a foreign country. Nor did any country want to have a foreign power acquire imagery of its territory without permission.

For several years, an international debate took place concerning the potential infringement on territorial sovereignty by those states possessing the ability to observe and image the Earth's territory from space. Apart from the Chicago Convention governing airspace, the only prominent international agreement regulating the use of non-sovereign territory was the Antarctic Treaty of 1960, necessitated by conflicting claims of sovereignty that had been made based on various criteria including flag planting by the UK, geographic proximity by Chile, Argentina and South Africa, and by continuous occupation by the US who had operated a base at the South Pole since 1957. Claims of a similar kind would be made in the realm of outer space in the 1960's with photographic maps of the Moon and Mars allowing prominent features to be named in national languages (rather than the traditional Latin), and space mission proposals that included 'flag planting' ceremonies on celestial bodies.

Based on a recognition that the vast, desolate, inhospitable, and relatively unexplored Antarctic continent would render its economic development unlikely, the Antarctic Treaty had been

established to ensure the peaceful and cooperative use of the continent. In part due to the shared physical attributes of Antarctica and outer space at least in terms of the potential for human habitation, the establishment of Antarctica as a ‘global commons’ supported an argument for preserving space as a peaceful shared commons of humanity. When considering the preamble to the Antarctic Treaty: “it is in the interest of all mankind that Antarctica shall continue forever to be used for peaceful purposes,”¹⁰⁹ it is clear that this idealistic symbol of international cooperation was influential in the formulation of an outer space regime.

In the few years following the establishment of COPUOS, wrangling continued towards inscribing the *Legal Principles* of 1963 into an international treaty instrument. The *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*, known commonly as the Outer Space Treaty (OST) entered into force on October 10, 1967. The OST designated outer space as a global commons, ultimately providing the legal basis for satellites to travel over any point on Earth.

Besides the precedent of the ‘commons’ aspect of the Antarctic Treaty, the outer space regime was also based on earlier arms control agreements that banned the testing or deployment of nuclear or other weapons of mass destruction in space. Interestingly, the treaty also curtailed any scientific experiments with potentially detrimental ecological effects from taking place in space. In a relatively short period of time, negotiations primarily between the two superpowers of the day resulted in a series of international agreements which largely established the norms for the development and use of outer space. While not perfect agreements, the incremental steps taken by the US and the Soviets to ensure that outer space could not be appropriated by any one nation

¹⁰⁹ The Conference on Antarctica: Conference, Documents, the Antarctic Treaty, and Related Papers (Washington, DC: Department of State Publication, 1960), p.61

were seen as major milestones for global cooperation and peace-building, miraculous events considering the Cold War tensions between the two Superpowers at that time.

Despite the established norms, NASA was perhaps influenced by other segments of the US space program in developing a position that existing international agreements allowed any state to conduct any activity in space provided it did no harm to other states. This interpretation would hold great significance for the Canadian remote sensing industry. The US perhaps as a result of compelling security threats at the height of the Cold War would find itself driving increasingly towards superiority in space technology and know-how, becoming globally influential in its interpretation of the international norms for space development. Canada for its part would be forced to gain as much knowledge of the technology as possible, allowing better control over the use of the data that it would continually have to fight for access to receive from its US neighbour.

The need for Canadian scientists to appeal to a broader international community to secure access to remote sensing technology and geospatial data establishes one clear and early distinction between the trajectories that civilian remote sensing programs would have in Canada and the US. In one respect, Canada's smaller population of scientists and its less prominent defence research program created a need for international collaboration. In another respect, sheer investment dollars were limited for research and development, necessitating ingenuity, efficiency, and the sharing of information from willing international and private partners. In the US, resources in each of the areas of technically trained personnel, defence and civilian research, and funding sources were more plentiful, allowing the remote sensing community in the US to maintain a more isolationist policy while becoming the predominant actors in both satellite manufacturing, image processing and information technology.

As a result of the US interpretation of international legal instruments that advantaged its use of space over other countries, and in response to the perceived competitive ruthlessness of dominant US actors, Canadian remote sensing practitioners pursued the formulation of an international legal regime for the operation of remote sensing satellites which would include the transfer of technology and the establishment of an international network of readout and ground data handling centres. This early recognition by Canada that remote sensing technology had potential global value and importance – perhaps even necessitating multilateral regulation – did not please NASA administrators, but would establish a basis for several later proposals recognizing the value to the international community of EO technologies.¹¹⁰ Increasing pressure was placed on the US to comply with the spirit of international agreements to develop and explore space for the benefit of all, and to be guided by the principle of cooperation in conducting all their activities in outer space with due regard for the corresponding interests of other states.

In spite of its persistent ‘go-it-alone’ stance in space development, NASA finally bowed to international pressure, agreeing in 1969 to provide Canada with access to ERTS data at a Canadian facility. After a series of negotiations, the Canada/US Earth Resources Agreement was signed, placing Canada and the US together again on an early road towards cooperation in civilian Earth remote sensing development. NASA’s change of policy direction was a clear expression of its confidence as a leader in space technologies at the close of the decade, having won the race to the Moon and seeing a need to expand its now extensive aerospace industry into the international marketplace. While at first cautious about the transfer of data stemming from its remote sensing satellites, it became clear that reliance on geospatial data acquired from US controlled space platforms could ultimately advantage the US both strategically and commercially. This era

¹¹⁰ Canadian Centre for Remote Sensing, “Remote Sensing Then and Now-Early Beginnings 1960-66”, NRCan. http://www.ccrs.nrcan.gc.ca/ccrs/org/history/history1_e.html [12 March 2003]

marked the beginnings of an outward expansion of the US in its encouragement of Canada and many other states to invest in US space systems, commencing with the establishment of ERTS ground stations around the world at a modest annual licensing fee of US \$200K each.

While space development was clearly taking off at the close of the decade with major breakthroughs reported almost weekly including the Moon missions, plans for Skylab and Canada's successes with ionospheric research satellites, most important for civilian, commercial and military remote sensing development was the increased sophistication of space-based sensors and data analysis. In particular for the civilian sector, NASA's pursuit of the ERTS platform in the early 1970's would begin to reveal for the first time on a global scale, signs that human development and resource use were having major deleterious effects to the Earth's environment.

5.1.2 Part II – A North American Earth Observation Industry (1970-1980)

At the beginning of the 1970's data from US satellites was being received at Canada's Atmospheric Environment Centre, demonstrating the value of satellite-based EO for weather forecasting. Canada would soon become the first country in the world to have a commercial geostationary communications satellite network. Beyond the proven utility of relaying communication signals and monitoring weather, satellite monitoring of the Earth's surface geography began to receive wider recognition as a valuable application for space technologies, particularly in the lead up to the launch of the ERTS platform and the plans in Canada to receive data from this satellite.

Due to Canada's vast and predominantly remote landmass and its economic dependence on natural resources, the potential value of remote sensing was highlighted prominently in a 1970 interdepartmental government report titled *Organization for a National Program on Remote*

Sensing of the Environment. The report proposed the following objective for a national remote sensing program in Canada:

To produce in a timely and effective manner, remotely sensed data and derived information needed for the management of Canada's natural resources and environment, and to perform and support research and development on the collection, processing and interpretation of such data.¹¹¹

What followed in 1971 was the formal establishment of the Canada Centre for Remote Sensing (CCRS). The community of engineers and scientists observing the growth in this sector grew substantially with the accompanying investment made to prepare for receipt of ERTS data. The Canadian approach to remote sensing development would necessarily involve both provincial and federal levels and various departments of government, private industry and universities due to the imperative to catch up to speed with developments in the US. Due to limited resources and the procurement policy followed by the Canadian government, CCRS would contract out as much work as possible. A handful of companies and a partnership between CCRS and the Canadian Air Force (CAF) established an airborne remote sensing program with the CAF providing aircraft and personnel. While the government (with the urging of the private sector) used civilian contractors whenever possible, the evolution of early CCRS programs involved a large degree of cooperation between government departments.

According to CCRS records, the airborne program was a fundamental stage in the Canadian development of a space-based remote sensing program due to the multiple users that became involved from government, universities and industry. Each group used the aircraft for experimental flights and the program accelerated the innovation of many new sensors with users

¹¹¹ Canadian Centre for Remote Sensing, "Remote Sensing Then and Now-Early Beginnings 1960-66", NRCan. http://www.ccrs.nrcan.gc.ca/ccrs/org/history/history1_e.html [12 March 2003]

from all disciplines acquiring detailed airborne data over their test sites – a necessity in validating experimental remote sensing interpretations from satellite data.

With increasing levels of out-sourcing to private industry, the Canadian approach to remote sensing development saw a decreasing role for the Canadian military, and the involvement of more than 140 civilian scientists and engineers involved in the next major initiative which involved preparation of a ground station at Prince Albert, Saskatchewan and the installation of image processing and analysis technology at CCRS headquarters in Ottawa. In preparing for the use of the data it would receive, CCRS published a document in 1971 entitled *Observables and Parameters of Remote Sensing* which discussed the problems in every-day decision making encountered by environmental and resource managers. The report examined decisions that could be addressed by information derived from remote sensing. In identifying specific environmental or resource parameters that could be measured (observables), remote sensing specialists were able to focus on environmental and resource management problems holistically instead of first developing technologies and then looking for applications. Due to this philosophical approach and the emphasis placed on collaboration within a relatively small community of remote sensing professionals, a *demand* driven rather than a *supply* driven approach was developed, with strong emphasis on natural resource and environmental applications for remote sensing.

Importantly for Canada at this stage of its remote sensing development was a conscious policy pursued between 1967 and 1971 by the Trudeau government to dramatically restructure Canadian foreign and defence policies, resulting in the demilitarization of Canada's space program. Military resources were taken up by the civilian sector in the early days of remote sensing

technology development in Canada, but unlike US programs, the Canadian military had no major or direct project guidance over remote sensing programs.¹¹²

Widespread scientific applications of satellite communications and remote sensing began to appear prominently in the literature leading up to 1972 when Canada deployed its Anik-1 satellite. This, the world's first domestic geostationary communications platform, enabled Canadian television signals to be broadcast to all reaches of the country, addressing one of Canada's existing sovereignty concerns that it be able to provide communications access to its remotest northern communities. The US launch of ERTS in 1972 – later to become the world's first civilian remote sensing satellite when renamed to the Landsat program – signalled recognition of the strategic and economic potential of geospatial data in Canada and the US, particularly as used for resource management. Through 1974, Landsat transmitted over 100,000 images covering 75% of the Earth's land surface, with more than 300 US and foreign partners receiving data. Both Canada and the US had surmised that an important measure of the success of the Landsat program would be data sales. Canadian industry had by this time built substantial expertise in data handling and ground station design, knowledge that was increasingly being sought internationally.

Also in 1974, the National Oceanographic and Atmospheric Administration (NOAA) was established in the US, quickly becoming a major leader in infrared and other new imaging techniques for measuring such phenomena as atmospheric density, foliage concentration and the expansion of cities. In the non-civilian space programs in the US, a need for economy, maximum use of new technologies, and reduced human resources following the Vietnam War led to the armed services combining most of their mapping and charting capabilities into one organization, resulting in the formation of the Defence Mapping Agency (DMA). This restructuring

¹¹² Godefroy (2000), p.51

symbolized the beginnings of a step-wise trend that recognized the high degree of overlap between civilian, defence and intelligence remote sensing capabilities in the US.

NOAA's Geostationary Operational Environmental Satellite (GOES) and other programs provided readable interpretations of satellite imagery, which by the end of the decade were becoming more widely available to the public and revealing further evidence of human impacts to the Earth environment and atmosphere including most importantly, the ozone hole over Antarctica. GOES imagery is still a mainstay in weather reporting and forecasting across the North American continent and around the world, additionally providing certain remote Pacific island territories with telecommunications services from geostationary orbit.

NASA was also proceeding on Seasat, designed for observing the Earth's oceans with active microwave instruments. Again Canada approached the US for data access and was initially rebuked as in the case of ERTS/Landsat, with the US suggesting that Canada should substantially contribute to the program in exchange for data rights. Following additional requests for access from the European Space Agency (ESA), consistent with international norms established to ensure access to overhead imagery, NASA was forced to relent to the Europeans and Canada, allowing for their readout of Seasat data.

At the time of the Landsat-2 launch in 1975, research activities were focused on satellite remote sensing as a basis for studies of land resources, particularly in remote environments.

Representative of early research publications representative of these activities are Richard Jolly's (1976) survey of multidisciplinary approaches to development planning, Paul Krumpke's (1976) bibliographic index to remote sensing site investigations of natural and agricultural resources throughout the world, and summaries by the Canadian Advisory Committee on Remote Sensing

(1976) and L. P. White (1977) on methods for measuring soil moisture and groundwater via satellite. In 1976, an international symposium for 'Earth Observation and Environmental Control' was held in Canada to which 26 of the world's leading experts in the field were invited.¹¹³

Early studies of EO systems for resource management and environmental planning (Lintz et al., 1976; Morley et al., 1977) and Buttrick's (1978) dissertation on alpine vegetation ecology further demonstrated the widespread civilian uses of infra-red imagery for differentiating various vegetative zones and regions of varying sensitivity to climate and geomorphology. Professional associations and societies of remote sensing scientists and professionals continued to grow during the 1970's stemming out of the related areas of meteorology, atmospheric and Earth sciences, geomorphology, oceanography and cartography.

While academic interest in remote sensing and its perceived value to some in the resource exploration sector gave encouragement for the Canadian remote sensing market, applications were still limited and challenges were still being felt in establishing a domestic market and securing long-term funding for applications development. Evidence existed of a very healthy civilian remote sensing market in the US, with many more government departments engaging in space-related activities throughout the 1970's but the investments were all primarily public funds. While the US market remained buoyant on these investments by government agencies, the Canadian government was very risk averse, finding the concepts of remote sensing or a Canadian role in space development to be so revolutionary that there was natural human resistance to the concept in many quarters. The introduction of CCRS as a major new organization within the Canadian government that was based on the use of a new set of relatively unproven technologies

¹¹³ Morley et al. (1977). *Op. Cit.*

has been compared by past CCRS director Lawrence Morley to initiating a new company in the private sector, requiring total commitment and a high degree of risk tolerance.¹¹⁴

As CCRS was establishing its bottom-up effort, growth was slow with little attention paid to applications development. An assumption was made that federal and provincial government departments would buy in to remote sensing as data became available. In fact, several departments generally considered that remote sensing had little to contribute to their scientific activities, exemplifying the cautious approach taken by public institutions in Canada. According to Morley, senior levels in the Department of Agriculture felt that there was nothing remote sensing could tell the farmer that the Earth-bound scientist didn't already know.¹¹⁵ Senior management within the Geological Survey of Canada were also reluctant to use remote sensing data according to Morley. Perhaps surprisingly (as the Canadian Ice Service is now the prime user of RADARSAT data in Canada), the Atmospheric Environment Centre was also initially resistant to using satellite observations for ice monitoring. Early supporters included Environment Canada that used Landsat platforms to relay data from stream gauge platforms to central locations, and the Forestry sector that saw the value of remote sensing for monitoring Canada's forests.

Indications from the early days of Canadian remote sensing efforts show that international markets opened up to Canadian companies long before domestic markets took hold. To attempt to encourage domestic markets, the distribution and use of satellite data by the private sector and the development of new sensor technologies, a sensor working group and unsolicited proposal fund was initiated by CCRS. With these programs and the official status of CCRS, cross-border collaboration in remote sensing became growingly possible and Canadian EO companies received

¹¹⁴ Canadian Centre for Remote Sensing, "Remote Sensing Then and Now-Early Beginnings 1960-66", NRCan. http://www.ccrs.nrcan.gc.ca/ccrs/org/history/history1_e.html [12 March 2003]

¹¹⁵ Ibid. (no pagination)

significant benefits. A NASA/CCRS working group was established to discuss the need for data standardization and information sharing that would benefit both industries. When Brazil, Europe, Australia and Japan also requested to receive data from Landsat, the NASA/CCRS committee expanded to the Landsat Station Operator's Working Group which increasingly had an international focus.

Conferences and symposia of scientists and engineers in the geospatial sector in Canada and the US began to partner internationally, helping to promote world-wide research that produced many new studies and applications for the emerging technology. In 1978 with a third Landsat deployment,¹¹⁶ Terje Lund's (1978) volume of applications for remote sensing in monitoring environmental pollution and resources was accompanied by several major atmospheric studies (V.E. Zuev et al., 1978; H.-J Bolle, 1979), ocean monitoring investigations (ESA, 1978; International Council of Scientific Unions, 1978) and major advances in digital image processing and terrain modeling (Bernstein, 1978; American Society of Photogrammetry, 1978).

In 1978, France introduced the concept of an International Satellite Monitoring Agency to the United Nations, building on previous proposals that had received broad support from many nations.¹¹⁷ France noted that the technological progress made in the field of EO constituted a new development in the management of international affairs and proposed that "this new monitoring method should be placed at the service of the international community."¹¹⁸ While Canada supported the French initiative, the US did not, as it had advanced capabilities in space at the time and wanted to maintain exclusive control over the data they could gather.

¹¹⁶ Landsat-3 was launched the same year that Landsat-1 operations were terminated (1978)

¹¹⁷ for a thorough summary and discussion see Kurtz (1957, 1969)

¹¹⁸ as quoted in Dorn (1987b) http://www.rmc.ca/academic/gradrech/dorn19_e.html [May 10, 2004]

With the early Landsat pixel resolution of 80-meters and the relatively cumbersome image processing and computing techniques available, the use of remote sensing imagery in resource management was best suited to large-scale development projects such as those in the mining and, oil and gas sectors. One Canadian example of an early project of this type is M. D. Thompson et al's (1978) ecological habitat mapping of parts of north-western Canada for the Alberta Oil Sands Environmental Research Program. Applications for remote sensing in geomorphology and mineral exploration were undertaken (T. H. Verstappen, 1977; William L. Smith, 1977) and even more diverse projects such as the mapping of the Lunar surface took place using the coarse resolution offered by existing remote sensing satellite monitoring methods.

Marking the evolution of the Canadian interest in Synthetic Aperture Radar (SAR) technology, CCRS (1976) reported on applications of remote sensing for seaborne surveillance and sovereignty, making a further case for Canadian involvement in NASA's Seasat program. In developing data processing techniques for Seasat, MacDonald Dettwiler (MDA) of Canada was successful in producing the world's first digital SAR processor both for aircraft and satellite use, eventually also being adopted for the US program. In 1978 when Seasat was launched, its collection of data on sea-surface winds, ocean topography, temperatures, wave heights, length and direction as well as ice features proved very interesting to Canada, particularly in considering sea navigation in the far north where certain competing claims over access to transportation routes raised questions for Canadian officials over how to ensure sovereign control of such remote, relatively uninhabited regions. MDA's SAR technology also represented an important Canadian strategy to address Canada's energy needs in response to the oil crisis of the late 1970's. During this time, Canada conducted an extensive drilling program in the Beaufort Sea as part of its search for alternative sources of oil. SAR technology's ability to provide Earth monitoring independent

from long periods of winter darkness and summer cloud cover made it an extremely useful tool for monitoring Canada's northern regions.¹¹⁹

Past challenges in assuring timely access to data from US satellites had caused many remote sensing professionals in Canada to consider the options of acquiring its own Canadian-owned satellite remote sensing technology. Canadian telecommunication and scientific satellites had proved that Canada's technological abilities were sufficiently developed in space to progress to the EO business. CCRS had made significant progress, through its involvement of Canadian industry, in establishing a strong internationally-recognized expertise within Canada for many aspects of civilian remote sensing. The one hurdle to Canadian industry was their reliance upon US access policies and data. When NASA decided in 1979 not to continue with its Seasat program for which Canada had benefited greatly, the Canadian Working Group on Satellites and Ground Station Engineering immediately prepared a recommendation that Canada proceed with its own radar satellite. The recommendation received early Cabinet approval, marking an increased interest by the Canadian government in asserting sovereign control over its territory, and also indicating the growing recognized value of remote sensing in Canada.

Earlier international concerns over the sovereignty aspects of EO technologies continued during the 1970's, partly out of a growing awareness by the international community that their national territories were being observed, mapped and studied by foreign-owned satellites, despite established international norms that encouraged space-faring states to develop applications for the benefit of the 'common good'. Efforts to apply remote sensing to address issues in developing countries and for issues of international concern such as global food supply monitoring (National Research Council, 1977; Otterman et al., 1978) and verification of arms-control treaties supported

¹¹⁹ http://www.rsi.ca/products/sensor/radarsat/rsiug98_499.pdf [Oct. 29, 04]

a freedom-of-information perspective that reduced the legitimacy of territorial sovereignty claims to remote sensing data by imaged-states. To curb international concern over the 'open skies' norm which was emerging for satellites, countries around the world felt an imperative to participate in the remote sensing market by planning for ground stations and data handling facilities of their own. In turn, this internationalization helped to expand US prominence in satellite technology and expertise while Canadian markets for the supply of ground stations and data processing techniques were similarly expanded.

At the close of the decade, sovereignty concerns were shifting to concerns of uneven development brought on by space technologies. While technologically advanced nations enjoyed international expansion of markets for their satellite and remote sensing technologies, further proposals for multilateral regulation of space development and EO in particular were voiced at international meetings. Dominant space-faring nations, primarily the US, did begin to recognize that other nations would soon emerge as satellite operators themselves but instead of supporting multilateral regulation of space technologies and development as a means to prioritize global needs over national programs, commercial development would become the growing concern. Early competition in remote sensing data sales had initiated a process in Canada¹²⁰ for the reproduction and selling of Landsat data that would prompt the US government in 1979 to recommend a transition in the continuation of the Landsat remote sensing platform to the private sector.¹²¹

¹²⁰ CCRS in 1979 took the unusual step for a scientific government agency to hire an experienced marketing person to boost data sales.

¹²¹ US Presidential Directive 54 under President Jimmy Carter urged the privatization of Landsat.

5.1.3 Part III – Between Internationalization and Privatization of EO (1980-1990)

Earth and environmental science reliant on space technology truly evolved in the context of strengthened international scientific cooperation during the 1980s. Cooperative agreements were signed to deploy sensors on foreign satellite platforms, the first Canadarm was deployed, Canadian astronauts began participating in NASA missions, and several countries partnered to pursue the International Space Station.

Experiments were jointly undertaken to improve the understanding of the Sun's energy absorption and re-emission, and the effects of this on the Earth's climate. These observations were also used to determine the effects of human activities such as the burning of fossil fuels and the use of ozone-depleting substances. These experiments provided ample scientific support to future international environmental agreements such as the Vienna Convention for the Protection of the Ozone Layer in 1985 and the Montreal Protocol of 1987. Discoveries of global environmental problems in part made possible by civilian space technologies increased the prominence of EO as a critical science-based information tool in the public and private sectors around the world.

Earlier political concerns in the international community over satellite reconnaissance had concentrated on the issue of space observation as an infringement on territorial sovereignty, but increasingly, international norms recognized the apparent value of transparency in Earth observation from space, based on sharing of scientific information. While no significant progress had been made from earlier proposals to establish an international satellite monitoring agency, additional applications for remote sensing in international affairs began to receive wider recognition. US proposals for the formation of a global consortium for civil satellite remote sensing development (McLucas, 1985a) and the creation of an 'Open Skies Agency' that could

receive data from US satellites for distribution throughout the world were symbolic of not only the growing strategic value of remote sensing to international affairs, but the pressure for states like the US to remain ahead of the curve of development. The US desire to remain on the leading edge of remote sensing both technologically and economically was increasingly leading it to share its achievements with the world, on condition that it received economic opportunities and the right to control potentially sensitive data. According to McLucas (1985b) at the time, the US government was increasingly facing the prospect that high-quality imagery from space, previously available only from systems under close government control, would become widely disseminated by commercial organizations in the near future.

The 1980's indeed saw a further explosion of satellite technologies in a growing number of countries and an increasing sophistication of sensors used for EO. The mid 1980's also saw the dawning of the Information Age, with imagery and associated data now being easier and cheaper to handle, process, archive and distribute creating further opportunities for the global distribution of remote sensing data. Landsat 4, launched in 1982 carried a 'thematic mapper' imaging sensor in addition to the multi-spectral scanner used on the first three Landsat satellites. "In its first few days of operation, the mapper demonstrated its ability to produce data of such detail and clarity that its use represented a major advance in Earth observations from space."¹²² Indeed, Landsat-4 increased the image resolution available for civilian projects to 30-meters. France's Système Probatoire d'Observation de la Terre (SPOT) emerged only a few years later however, offering 10-meter resolution satellite imagery on a commercial basis. This new actor in the EO business symbolized the beginning of international competition in commercial satellite imagery.

¹²² NASA <http://www.earth.nasa.gov/history/landsat/landsat4.html> [accessed May 18, 2004]

Concern about loss in the marketplace of US multi-spectral imagery to SPOT as well as to Helios (launched by India, Japan and a European consortium) created two camps. The first camp was comprised of industry, environmental-data users and a scientific community who felt that US data policies were overly restrictive, stifling to business, and limiting for access. A second camp was comprised of the military and intelligence community who advocated strict control on the distribution of satellite Earth observational data and imagery.

Privatization studies¹²³ were accelerated during the 1980's resulting in decisions not to privatize operational weather satellites as they were considered to be providing a service for the public good.¹²⁴ In spite of warnings that substantial government subsidies would initially be required to make development of a private EO sector feasible, the US did proceed with the 1985 creation of the Earth Observation Satellite Company (EOSAT) selected to operate the Landsat system.¹²⁵ EOSAT received exclusive rights to market data and collect foreign ground station fees for a ten-year period. These steps marked an increasing trend within the US to seek dominance for its technology and data, believing that the most neutral and efficient means to achieve this would be through the private sector.

In 1986, the UN passed a resolution inscribing the *Principles Relating to Remote Sensing of the Earth from Outer Space*, which officially recognized the importance of remote sensing to international governance, and formally established certain 'rules of the road' to be followed by countries involved in remote sensing technology development. Specifically, the UN Principles reaffirmed the 1967 OST in calling for remote sensing activities to be "carried out for the benefit and in the interests of all countries, irrespective of their degree of economic, social or scientific

¹²³ PL 97-324 (1984) instructed the US Secretary of Commerce to study the privatization of Landsat

¹²⁴ PL 98-166 (1984) prohibited the US government from privatizing the operational weather satellites

¹²⁵ PL 98-365 (1984) established the process for commercialization of the land remote sensing satellites

and technological development, and taking into particular consideration the needs of the developing countries.”¹²⁶ The UN Principles also affirmed an existing default norm that legitimated the imaging by satellite of any place they fly over. This de-facto ‘open skies’ policy required that the sensed state would have non-discriminatory access to the imagery at a reasonable cost, but did not place any obligation on the sensing state for notifying countries of its actions or the availability of imagery of foreign territory. In essence, a reading of both the 1967 OST and the 1986 UN Principles indicate a lack of any precise regulatory measures protecting either the sovereign interests of states or the needs of the international community.¹²⁷ Principle XII of the 1986 document that enables sensed-states to have reasonable access to imagery acquired by foreign satellites has been interpreted in a manner that allows no direct knowledge of whether imagery exists or by whom or for what purposes the imagery was acquired to serve.

In the early phases of its space program, Canada had decided not to pursue a specifically military program, in part as a result of the Pearson and Trudeau Liberal governments’ direct interpretation of prevailing international norms and treaties that designated space for peaceful purposes only. The lack of an autonomous space program in Canada placed international cooperation at a high priority for achieving Canadian objectives in space. An example of Canada’s engagement with the international community in pursuit of space development for peaceful global governance is Canada’s 1986 PAXSAT study. This proposal stemmed from a growing awareness that the OST contained no effective verification or compliance mechanisms to ensure weapons would not be deployed in space. With Canadian government and industry already collaborating on the development of its own radar-based civilian satellite system to become known as RADARSAT,

¹²⁶ United Nations (1986) UN Resolution 41/65

¹²⁷ “Principles Relating to Remote Sensing of the Earth from Outer Space” Principle XII, United Nations General Assembly, New York, Dec. 3, 1986

the PAXSAT study suggested that a space-to-space remote sensing system (PAXSAT A) and a space-to-ground observation system (PAXSAT B) could help verify arms control regimes both in outer space and on the Earth's surface.¹²⁸ While the proposals garnered wide international support in principle, they were met with a certain lack of enthusiasm by the more powerful space faring nations which besides the European consortium of ESA, now included France, Japan, China, and India, who were wary of any activities that might hinder the development of national space industries.¹²⁹

While the notion of international cooperation in the use of space had been enshrined in international treaties and norms by the close of the decade and was the basis for increasing levels of trans-national collaboration in space, the promise of commercial exploitation of the EO industry continued to reduce the likelihood that multilateral groups such as the UN would ever play a role beyond coordination and dissemination of information such as launch notice and orbit registration. Even serious proposals for the establishment of international EO systems incorporated the interests of specific national space programs and projects. By the end of the decade with certain valuable space orbits becoming sought-after by over 10 space-faring countries, France delivered yet another proposal to the UN for the creation of a space surveillance system consisting of radar and optical sensors to track the trajectory of space objects.¹³⁰ Again, no consensus was reached for various proposals ranging from arms control to disaster and environmental monitoring. The changing political climate and uncertainty in the final years of the Cold War perhaps resulted in a lack of sufficient trust and true global cooperation required for

¹²⁸ Foreign Affairs Canada www.dfait-maeci.gc.ca/arms/outer3-en.asp [accessed May 19, 2004]

¹²⁹ by 1988, India was operating a suite of remote sensing satellites, marketing sub 10-meter resolution imagery to its commercial partners

¹³⁰ France's 1989 proposal, presented in the Conference on Disarmament (CD/937 and CD/PV.570), became known as the international trajectory centre (UNITRACE) proposal.

states to create conditions that would not advantage one state over another. Instead, bilateral arrangements were forged between like-minded states enabling the provision of commercial trade regulated by national laws and domestic policies.

In the West, bilateral relations between Canada and the US were forcibly improving throughout the mid-1980's under a Conservative Mulroney government in Canada. In response to the US announcement of its Strategic Defence Initiative (SDI) in 1983, the Canadian government by 1986 had highlighted a need for Canada to have a definitive military space policy. Although the 1987 Canadian *White Paper on Defence* showed no significant interest in taking advantage of space as a security multiplier, Canada did pursue an updated network of ground-based radar monitoring stations based in the Canadian Arctic.¹³¹ During this period, Canada had been reconfiguring its defence policy in response to new technologies and awareness of the importance of interoperability between Canada and its allies, particularly the US. Canadian discussions on establishing a military space program had proceeded to the point that resources in the order of \$150 million per year over five years were recommended to help deploy up to twelve military satellites.¹³²

5.1.4 Part IV – New Priorities: Mission to Planet Earth and Beyond (1990-2000)

Following the economic collapse of the Soviet Union, major US military budget surpluses and subsequent cut-backs on military spending in various countries contributed to a liberalization of the defence industry which in turn saw an increased transfer of military satellite observation technologies into the civilian and private sectors. The end of the Cold War was also marked in Canada by disbandment of the National Defence Headquarters Directorate of Space Doctrine and

¹³¹ Godefroy (1998) no pagination

¹³² Recommendations of the Senate Special Committee on National Defence as cited in Godefroy (1998)

Operations. The new national space program in Canada marked by the establishment of the Canadian Space Agency (CSA) turned again towards a focus on international cooperation and civilian, commercial uses for remote sensing technologies. Again of significance for the future of the Canadian remote sensing industry, no military space program was envisaged.¹³³

The end of the Cold War renewed an opportunity for states to again explore the concept of Open Skies. An early US proposal for an *Open Skies Treaty* had been revived by the Canadian government in 1989 to encourage reciprocal openness by all participating states through approved aerial overflights designed to allow signatory states to observe one another's military activities and institutions. It was envisaged that information only previously available through US or Soviet military satellite systems would be available to all parties to such an agreement, marking a compromise for states not willing or able to invest in their own indigenous space-based EO industries. In addition, satellites were understood to follow predictable orbits, possessing limited manoeuvrability, whereas aircraft were available to all states, and could fly anywhere at anytime - something which gave states hitherto unparalleled flexibility for surveillance. Perhaps the most important principle to this proposal was that political commitment was needed between states to symbolically and legally entrench new values of openness and transparency in international affairs, a process that began to redefine the security relations between states at the end of the Cold War.

Technical advances by the US Department of Defence (DoD) and Department of Energy (DoE) provided for the prospect of smaller, lighter, more specialized and less costly remote sensing systems. The DoD also gained substantial experience with the use of Landsat's multi-spectral imagery during the planning and execution of the 1990-1991 Persian Gulf War and began to find

¹³³ www.forces.gc.ca/menu/consult/current_policy/defence_portfolio/section_3_e.asp [October 12, 2004]

the information useful for creating wide area maps for operational support.¹³⁴ Landsat data proved at times more versatile than military or intelligence imagery that provided high resolution in the optical range, but had very narrow fields of view. Landsat data could be combined with other available satellite images such as SPOT for lower cost, and could be unclassified for wider dissemination and planning use.

Realisations that the technical advancement made in military remote sensing had provided only a small benefit to the civilian and private sectors over the past several decades resulted in strong critiques of state-controlled satellite surveillance programs. The history of remote sensing during the Cold War era has been described as a “Cinderella story in which civilian applications enjoyed the occasional hand-me-down, while only their military stepsisters were invited to the ball.”¹³⁵

Early US attempts to privatize Landsat failed due to lack of revenue, restrictive policies over data access, inadequate government funding to support follow-on satellite systems which created uncertainty, and the growing presence of non-US civilian EO satellites. During this time, computer costs continued to drop and demand for GIS was growing rapidly, providing optimism for prospects of a commercial remote sensing industry provided that US policy could evolve in support of the private sector. The Department of Commerce (DoC) in the US would eventually streamline licensing for private satellite operators in a second major attempt to encourage development of a private EO industry.

The 1990’s saw Canadians participating alongside US astronauts on numerous shuttle missions, visits by both countries to the MIR space station, worldwide cooperation on the International Space Station, numerous scientific experiments and discoveries in space, and the further

¹³⁴ Dehqanzada et al. (2000), p.43

¹³⁵ Monmonier (2002), p.10

deployment of a suite of communications and imaging satellites including Canada's RADARSAT-1, a powerful microwave instrument designed to transmit and receive signals through clouds, fog, smoke, and darkness, and obtain high-quality radar images of the Earth in all weather. RADARSAT had involved many private firms in its development from the outset, although the commercial operation of the system was not initially planned for. The RADARSAT project office was supported by numerous federal and provincial government departments, agencies, private companies and their sub-contractors with almost all of the funding coming from public sources. RADARSAT was successfully launched by NASA in 1995 in exchange for data access rights.

In both Canada and the US, the 1990's would be characterized by increased international trade in satellite systems, sensors and ground stations, with dozens of US satellite systems and Canadian-made ground station and sensor technologies exported to such markets as Europe and Asia.¹³⁶ Concerns that these exports might contribute to a proliferation of sensitive military or weapons technologies grew, despite recognition by some governments that limited trade in civilian space technologies had strengthened international cooperation and expanded market possibilities for the geospatial sector. Nevertheless, the US response was to enforce stricter export controls on space technologies and satellite systems in particular, with ensuing claims by many developing countries that these controls amounted to market protectionism rather than enhanced global security. The private-sector in the US also claimed that irrationally strong export control measures were stifling industrial growth and reducing their international competitiveness.

¹³⁶ CRS Report 98-485, China: Possible Missile Technology Transfers From US Satellite Export Policy - Background and Chronology.

A separate trend from market protectionism brought on by national security concerns in the US was the concurrent focus in the civilian remote sensing industry to shift from technology and data collection markets to the production of information and descriptive products. By the early part of the decade, NASA had made the study of the Earth one of its top priorities, launching the "Mission to Planet Earth" project as its contribution to the US Global Change Research Program. With numerous international partners, this program would further characterize the thinning ozone layer and provide real-time views of the Earth's dynamic atmosphere, hydrological cycle and changing land-use patterns. For perhaps the first time, supported by the increasing use of global monitoring methods, the Earth was being conceptualized and studied as a complete ecological system by a growing number of research groups and institutions around the world.

Some examples of the many advances in international Earth monitoring in the 1990's include the Meteor-3/TOMS project which was the first significant US science instrument to fly on a Russian spacecraft, providing the main source of atmospheric ozone data until its completion in 1994. In addition, the Atlas experiments carried out on a series of shuttle flights during 1992-1993 were part of NASA's unified study of the Earth as a single, dynamic system. Other partners included Belgium, France, Germany, Japan, the Netherlands, Switzerland, the UK as well as the ESA. In 1996 and 1997, the US collaborated with Japan on various projects, including the Advanced Earth Observing Satellite – the first international space platform dedicated to Earth environmental research – and the Tropical Rainfall Measuring Mission, the first mission dedicated to observing and understanding tropical and subtropical rainfall – one of the most important but least understood parameters in global change.¹³⁷

¹³⁷ <http://trmm.gsfc.nasa.gov/> [accessed May 20, 2004]

With the first failed attempt at privatizing data sales from Landsat, and Landsat 4 and 5 operating well past their design-lives, government funding restrictions at one point suggested the possible demise of the Landsat program. However, strong opposition came from domestic users as well as from many foreign governments and international data clients as they had built programs that relied on the continued supply of Landsat data. While the US government committed to keeping the Landsat program afloat, it limited its role to that required for national security, foreign policy and public safety, and for minimizing the cost of data for government users and for the Global Change Research Program.¹³⁸ Eventually, the on-going debate between civilian and military data users and the difficulties encountered in privatizing Landsat provided the impetus for policy reform. The *Land Remote Sensing Policy Act* of 1992 transferred back authority for managing the Landsat program to NASA and DoD in recognition that the commercialization of Landsat had not worked. More importantly, this policy allowed private companies to build and operate EO satellites under government licence, responding to the growingly dominant market niche for satellite imagery being filled by non-US civilian EO satellites.¹³⁹

With the sharing of system development transferred back to the civilian and defence sectors, disagreement over sensor design and funding posed an increasing challenge along with the failed deployment of Landsat-6 in 1993. In light of these developments, NASA and DoD again went their separate ways in remote sensing satellite development, but this time with a national policy in place that promoted a certain degree of competition by the private sector.

Given new buoyancy by national policies in the US supporting commercial development in EO technologies, the technologically advanced nations would increasingly see space as a strategic

¹³⁸ US National Space Policy Directive #5 (1992)

¹³⁹ The Land Remote Sensing Act, Public Law 102-555, 28 Oct. 1992

part of economic infrastructure. Canada had responded to its own need to better coordinate efforts to capture the growing commercial opportunities in space and had formed the CSA a few years earlier with the mandate of promoting the “peaceful use and development of space for the social and economic benefit of Canadians.”¹⁴⁰ A major strategic direction for the CSA from the outset was to encourage the Canadian private sector to develop and commercialize space technologies. While the military importance of space evidenced by the 1991 Gulf War spawned a political debate in Canada over whether a military space policy and infrastructure should be developed, Godefroy (1998) has argued that “the creation of an all civilian CSA had reinforced the mindset that the military had no home in Canada’s space program.”¹⁴¹ While Canada eventually formed a Directorate for Space Development within the Department of National Defence (DND), its purpose was to respond to national sovereignty and security concerns emerging from the next generation of US satellites that would supersede the need for ground-based radar receiving stations in much of Canada’s north. Other sovereignty issues were primarily economic in the Canadian context, but also included concerns over illegal drug shipments, refugees, fishing zones and search and rescue. Government policies had long disallowed any military efforts to explore areas where immediate commercial benefits were not identifiable and this was fully recognized in Canada’s first comprehensive military space policy, tabled in 1992. Through this policy, DND had recognized that to justify the need for a military space program in Canada, it would have to express threats to Canadian sovereignty largely in economic terms and particularly through emphasizing the dominant role that marine and land-based natural resources played in the Canadian economy.

¹⁴⁰ The CSA was officially formed in 1989 with the its legislated mandate articulated in the 1990 Canadian Space Agency Act <http://www.space.gc.ca/asc/eng/about/mission.asp> [Nov. 6, 2004]

¹⁴¹ Godefroy (1998) no pagination

Without the dual-track approach of civilian and military sectors to contend with, EO development in Canada remained targeted towards the original goals of the civilian remote sensing program – environmental monitoring and natural resource management. In the US, the presence of multiple and overlapping EO sectors accompanied by a narrowing gap between defence imaging requirements and those available commercially created divergent investment strategies and multiple foci for the commercial EO industry in the US.

To further address the severe overlap in EO development that still existed across government departments in the US, Presidential Decision Directive 23 was passed in 1994, allowing for higher resolution imagery to be sold commercially. The newly formed Russian Federation had made available much of its early 2-meter black and white imagery from spy satellites and the French SPOT system was increasingly gaining a foothold in the satellite imagery market. The US policy response and the declassification, in 1995, of much of its own early spy satellite imagery, marked a perceived leap forward in global transparency and symbolized that earlier Cold War military threats to security had now been transformed into a series of foreign-origin commercial threats to economic security.

To attempt again to increase efficiency for its own operations and reduce overlapping surveillance and mapping missions, the CIA and DoD – the two other major US remote sensing developers besides NASA – agreed to reformulate the country's defence and intelligence mapping and imagery analysis efforts into a new organisation called the National Imagery and Mapping Agency (NIMA).¹⁴² Facing increased budget scrutiny due to their expense and perceived redundancy, overlapping civilian and military EO programs began to merge despite wide differences in mission priorities, organizational cultures and requirements. A primary example of

¹⁴² History of the NGA <http://www.nga.mil> [accessed June 2004]

this was the merging of DoD's Meteorological Support Program with NOAA's planetary weather monitoring program which began in 1994.¹⁴³

With new policies in place in the US allowing higher resolution satellite imagery to be commercialized, the privatization of services sought by military and intelligence agencies continued, presenting great potential for a strong commercial EO sector to emerge at the end of the 1990's. Industry projections for exponential growth in the EO and remote sensing fields were supported by the successes in the related telecommunications satellite industry. As the US was still the pre-eminent producer and user of EO satellites and technologies, the world market would generally be influenced to a great degree by the policy changes and private sector initiatives emerging from the US EO industry.

US exports of satellite technologies in 1998 were still seen by defence officials as a national security threat, eventually resulting in legislation that transferred jurisdiction for satellite export authorizations to the State Department from the DoC. For several years afterward, US satellite exports would fall, marking troubled times for geospatial technology firms in the US, while at the same time providing market opportunities for foreign firms including Canada.

Despite the struggling US EO industry at the end of the decade, Colorado-based Space Imaging had managed to launch its IKONOS-2 satellite, the first fully commercial, private-sector controlled and high-resolution remote sensing satellite. In 1999, Space Imaging began selling 1-meter panchromatic (black and white) imagery and 4-meter multi-spectral (colour plus near infrared) imagery to an international market.¹⁴⁴ This event marked a major milestone in the

¹⁴³ Johnson, Dana J. et al. (2001), pp.73-103

¹⁴⁴ SpaceImaging.com, OrbImage.com [accessed September 10, 2004]

private-sector EO industry that would in turn be followed by increasing interest and attention paid towards EO privatization and commercialization in both the US and Canada.

5.1.5 Part V – Emerging Trends Since 2000

By the year 2000, deregulation in the global telecommunications sector had caused a rapid expansion in private satellite ventures, with remote sensing platforms following suit. In states with a robust multi-faceted space program such as the US, EO was still a relatively minor element of the overall space sector in 2000 but in countries such as Canada that had no space transportation infrastructure, EO would grow into the largest space industry segment next to telecommunications. Developments in the 1990's that led to defence liberalization and policies supporting privatization of the EO industry resulted in overlapping satellite capabilities and mission objectives within private, commercial, civilian, defence and intelligence sectors. Particularly in the US where private EO firms were struggling under restrictive export policies for their technologies, civilian, defence and intelligence communities increased cooperation with private satellite companies through exclusive contracting arrangements and public-private partnerships to strengthen the private EO industry and to provide a level of imagery and data for government needs.

In 2000, breakthroughs in lightweight materials, precision spectrometers and detectors were demonstrated by NASA's deployment of the Hyperion hyper-spectral sensor that provided a new class of EO data for improved Earth surface characterization. Hyperion identified material properties of the Earth through hundreds of spectral bands that marked a leap forward from the tens of spectral bands obtained from Landsat. The sensor enables complex ecosystems to be

imaged and accurately classified and increases the ability of resource managers to select sites for exploration of specific mineral resources and to better monitor forest and agricultural inventories.

NOAA issued new regulations enabling the further commercialization of certain types of satellite imagery, including products from Landsat. This policy development placed civilian and private remote sensing firms in competition in the US with civilian imagery products often available at substantially lower cost than imagery from private firms. The new regulations further codified the licensing process for commercial satellite operators and established a shutter control policy for the US government. Industry advocates have argued that the new regulations are too restrictive, compromising the intent of the 1992 *Land Remote Sensing Policy Act*. The US also entered into the *Canada-United States Agreement Concerning the Operation of Commercial Remote Sensing Systems* in June 2000 in an attempt to harmonize policy and regulatory responses to high-resolution imagery being provided by commercial EO firms.

Attacks to the US on September 11, 2001 have also affected the viability and growth of the commercial EO industry, primarily seen in a return to tightened control over information and technology exports and the degree to which the defence and intelligence agencies are purchasing geospatial data and imagery. A 2003 survey by the American Society for Photogrammetry and Remote Sensing (ASPRS) has indicated that “restrictions implemented since 9/11 have had a net negative effect on about 40% of the organisations producing geospatial data” in the US.¹⁴⁵ A seemingly endless appetite for geospatial information by the US defence and intelligence agencies has kept the EO sector buoyant despite disappointing growth and decreasing exports witnessed in both Canada and the US since 9/11. Other factors resulting in recent decreased growth in the

¹⁴⁵ ASPRS (2004) pp.52-55

Canadian and US EO industries can be attributed to the downturn in global telecommunications and accompanying weakness in investor confidence.

Concerns over imaging rights and policies, shutter control and export issues have recently become very important to the health and viability of the commercial remote-sensing industry. Presently, over ten countries including the US, Canada, Russia, Japan, China, EU (through ESA), France, UK, India, Israel and Brazil operate high-resolution satellite EO platforms. Other states such as Turkey and Pakistan have expressed strong interest in purchasing data or developing indigenous remote-sensing satellites. Many other countries have chosen to purchase foreign satellite and ground station systems to gain a capability in space, including such countries as Algeria and Nigeria that have purchased EO technology to contribute to a disaster monitoring network for Africa. Surrey Satellite of the UK supplied the technology for less than \$US 10 million per satellite. According to the UN registry of objects in space over 20 individual states now possess a capacity for EO each indicating the rapidly depreciating cost to countries wishing to gain a presence in space and an EO capability.

Global competition in the EO market was at the heart of US policy efforts during the 1990's to maintain its predominance in remote-sensing. High-resolution satellite imagery – previously only captured by military platforms – has now become a market heavily pursued by the private sector. This type of imagery while useful for urban planning, insurance assessments, and the development of precision navigation maps is not always available or appropriate for environment and development planners, however, who rely on recent and easily updateable imagery as well as wider spectral data that goes beyond the optical and near-infra red regions. Optical imagery tends to be difficult to obtain due to cloud cover and darkness conditions restricting the reliability of

image acquisitions. Key trends in the remote sensing industry looking forward from 2000 have been identified to include a greater demand for high-resolution panchromatic, radar, multi-spectral and hyper-spectral imagery, and a continued need for more specifically designed, low-cost EO satellites and services that can compete with the more successful growth seen in the aerial remote sensing industry.¹⁴⁶

Smaller, cheaper, more specifically-tasked missions are being undertaken in the civilian sector, exemplified by the 2003 deployment of SciSat-1, tasked with improving understanding of ozone layer depletion, with a special emphasis on the changes occurring over Canada and in the Arctic.¹⁴⁷ Canada is contributing radar components to NASA's Cloudsat mission to provide the first global survey of seasonal variations in cloud structure to assist in climate modeling. The CSA is currently conducting mission concept studies in preparation for launch of a new hyper-spectral EO satellite called HERO (Hyper-spectral Environment and Resource Observer) that will "address the stewardship of natural resources for sustainable development and will support decision-making in the management of sensitive ecosystems within Canada and globally."¹⁴⁸ In Canada, it appears that these, like many other nascent technologies, are being promoted from within the technology and scientific communities and not the EO data user community, a factor that becomes increasingly important when viewed from the user-demand perspective where forthcoming technologies are less understood. In the US, NASA is planning for its Hydrosphere State Mission (HYDROS), to provide exploratory global measurements of the Earth's soil moisture and land-surface freeze/thaw conditions using radiometric and radar measurements for which Canada has contributed but for which commercial applications are not foreseen.

¹⁴⁶ Futron (2001), pp. 4-1

¹⁴⁷ www.space.gc.ca [accessed March, 2004]

¹⁴⁸ www.space.gc.ca [accessed Nov. 18, 04]

In the commercial sector, pure science and ‘public good’ applications are envisioned for such missions as Germany’s forthcoming RapidEye series of satellites and for the CSA HERO mission. These types of missions may provide a balance to the investments being made by the defence community, but government-subsidies provided to EO firms made all the more impacting by enlarged budgets for military and homeland security in the US following 9/11 suggest that the military market is greatest.

Beyond the countless civilian applications of satellite remote sensing imagery to urban planning, development, environmental assessment and resource management, some argue that the military-civilian-commercial crossover has provided new opportunities for increased transparency in international affairs including conflict resolution, human security and sustainable development. Examples include an examination of the pictures taken of mass graves in Bosnia by US military satellites in the investigation of the 1995 Srebrenica massacre (Parks, 2001) and the use of satellite images to monitor refugee camps (Giada et al. 2003a; 2003b). These applications can also be seen as providing convenient revelations based on public relations needs that do not emerge from extensive on-going information requirements. Another development has been the evolution of NGO’s such as ‘Public Eye’, a group focused on public advocacy and policy applications for high-resolution satellite imagery which may initiate on-going requirements for information.

While previous military technologies are continuing to emerge in the public sector, the merging of commercial, civilian and defence/security interests in space has not gone unnoticed by critics in the civilian, scientific and academic fields. Wide-ranging concerns have been expressed over the past decade regarding how a balance can be struck between the use of space technologies for environment and development applications against their continued use for military purposes

(Krepon, 1990; Gupta, 1995; Lenczowski, 1997; Diebert 1999). Environment and national security linkages have been exemplified in practice by the recent information sharing arrangements instituted in the US between the DoE, DoD and the Environmental Protection Agency, and also by the CIA's establishment of a Center for Environmental Security.¹⁴⁹ The MEDEA Project initiated by Al Gore, brought together CIA analysts and civilian scientists to assess the potential application of archived satellite imagery to studies of deforestation and climate change.¹⁵⁰ The Global Monitoring in Support of Environment and Security (GMES) initiative of the EU and ESA is another example of the convergence of environment and security discourses that may have an increasing impact on applications development for remote sensing in the commercial sector.

Important to the field of aerial remote sensing, the *Open Skies Treaty* officially entered into force in 2002 and has been described as “one of the most significant confidence and security-building measures signed”¹⁵¹ between Western allies and former Warsaw Pact countries, fostering a high degree of global confidence and international transparency. The long history and eventual success of this regime which provides for mutually agreed-to aerial overflights of foreign military installations suggests that a multilateral regulatory framework governing EO satellites may, over the long term be possible. In the commercialization cycle of EO that may follow a similar trajectory to that of satellite telecommunications and weather monitoring that has come under international regulatory control, global EO regulation may be warranted.

The level of impact of these new developments to the balance struck between private and public uses of satellite imagery still remains a key issue to be addressed. Below, an analysis of the

¹⁴⁹ Matthew (2002), p.119

¹⁵⁰ Ibid., p.118

¹⁵¹ <http://www.dfait-maeci.gc.ca/arms/european4-en.asp> [Oct.15, 2004]

official policies, marketing approaches and commercial ventures being sought by several private remote sensing operators in Canada and the US will enable some of this impact to be identified.

5.2 Analysis of Commercial EO Ventures in Canada / RADARSAT

The RADARSAT satellites use Synthetic Aperture Radar (SAR), instrumentation that transmits and receives microwave signals, beaming these signals off the surface of the Earth to obtain detailed images of the surface regardless of cloud cover or light conditions. The SAR sensor is a very versatile tool, capable of imaging in multiple modes. RADARSAT-1, currently operated by the CSA, provides spatial resolutions from 8 metres to 100 metres over areas ranging from 50 km² to 500 km². The instrument also offers a range of incidence angles allowing images to be obtained at various positions within each beam mode.

According to the CSA, RADARSAT was designed primarily to provide information about sea-ice coverage in Arctic regions and secondarily to provide information for use in monitoring forests, crop growth, oil spills and river flooding. Information from RADARSAT-1 has also been useful to geologists and archaeologists as the study of the surface texture and landforms of the Earth made possible by radar imagery allows much to be visualized that may not be apparent in the visible spectrum. Importantly, while all of these applications were envisaged, there was no commitment made by the user community other than the continuing interest of a few scientists. More remarkably, in Canada, sea ice has remained the principle application with geological reconnaissance mapping a second demand area. Operating since 1995, RADARSAT-1 has provided complete coverage of the world's continents, continental shelves, and polar ice caps and complete imaging of Antarctica has greatly helped in understanding climate change.

RADARSAT has been a state-led project which has had many private and international government partners. MacDonald Dettwiler and Associates (MDA), based in Richmond, British Columbia, has assumed ownership and operations for the follow-on satellite RADARSAT-2, scheduled to be launched in late 2005. As a civil government-initiated project, RADARSAT missions and applications priorities have been well described in public documents. Private industry, foreign governments and the international scientific community have had access to imagery purchased through Radarsat International (RSI), which, under licence from the CSA, has maintained exclusive worldwide distribution rights for RADARSAT imagery.¹⁵²

A network of 23 RADARSAT ground receiving stations around the world allows RSI and its partners to offer near-real time data delivery, as data is downlinked and processed at the nearest network station rather than being stored on board the satellite for downlink over Canada. For example, through the NASA-supported Alaska SAR Facility, RADARSAT-1 data is obtained and distributed to US investigators. The data is used to examine the Arctic sea ice on a weekly basis. Imagery from RADARSAT-1 has also been used to plan wireless communications, search for oil and gas, create new maps, route ships, monitor floods, and update forest cover inventories according to both CSA and NASA sources. The US Navy National Sea Ice Center uses the data to chart sea ice coverage to derive wind speed and direction, and river flooding.¹⁵³

Several public sector agencies have played a role in the setting of priorities for and the dissemination of information about the RADARSAT-1 remote sensing platform. Primarily, this information comes from two sources in Canada: CSA and CCRS. Together these two groups formulate EO data policies and lead the development and application of space technologies on

¹⁵² www.space.gc.ca and www.rsi.ca/news/media/rsi_prog.asp [accessed June 2004]

¹⁵³ www.nasa.gov [accessed June 2004]

behalf of the Canadian public. Interestingly, it is the Ministry of Foreign Affairs that has taken the lead on developing a national policy respecting the commercial uses of EO. In the private sector, RSI plays a dominant role in distributing RADARSAT imagery and derived information products and will maintain worldwide rights to RADARSAT-2 images, with the exception of imagery of the US. In 1998, MDA was selected to be the private-sector partner for the construction, operation and commercialization of RADARSAT-2 and in 1999, MDA acquired RSI consolidating its commercial autonomy over the future RADARSAT program.

With the present RADARSAT platform, almost all financing was provided for by public funds. With the follow-on platforms (RADARSAT-2 and beyond), a commercialization plan has been established to ensure private ownership and distribution rights for the geospatial data, and has included private and public funding for technology, applications development and satellite launch. Public funding is described as government “pre-purchase” of future imagery products to be prepared and distributed by RSI. Under the terms of the privatization agreement for RADARSAT-2, the Canadian government has agreed to provide \$225 million of the \$305 million (Canadian) needed to construct the satellite.¹⁵⁴ RSI has now become the major private-sector player in Canada for the management and distribution of geospatial information and imagery from RADARSAT and other remote sensing products including Landsat, IKONOS, IRS, ERS, QuickBird and ENVISAT.

Due to the planned operational transition from a government-controlled RADARSAT-1 platform to a privately-controlled RADARSAT-2 platform, a comparison can be made between application descriptions provided by government sources and by MDA/RSI for products made available by

¹⁵⁴ MDA press release: “Government of Canada Successfully Negotiates RADARSAT-2 Agreement with MacDonald Dettwiler: A New Earth Observation Satellite for Canada”, Vancouver, B.C. Dec. 18, 1998.

the same series of satellites. The following documentary analysis of both government and private-sector information on the purpose, missions and applications for the existing and forthcoming RADARSAT satellites will provide a qualitative context for examining the balance between public-good and private sector applications being pursued.

5.2.1 Canadian Space Agency (CSA)

While the underlying purpose of the RADARSAT series of satellites was to realize a degree of Canadian independence from foreign-controlled remote sensing programs, CSA's own background mission descriptions prioritize the establishment of an archive of world-wide SAR imagery using the various sensors of RADARSAT-1. This mission has included numerous individual mapping campaigns such as performed for the Antarctic continent, which was actually a priority of NASA, the provider of launch services for RADARSAT-1. The clear operational priority for RADARSAT from a government perspective has been for mapping and the generation of "wide area mosaics that facilitate investigations of terrestrial geology, geomorphology, vegetation, coastal features, wetlands, urbanization and ice dynamics."¹⁵⁵ Stereo data sets have been obtained by RADARSAT-1 for North America, Western Europe and Australia, indicating priority study areas for Canadian remote sensing practitioners and aligning well with some of Canada's closest historical allies, economic partners and foreign interests, and its scientific and technical collaborators. Current mapping missions are underway to obtain full SAR imagery for Saudi Arabia and China, two countries that also have great significance to Canada from economic, resource and political perspectives.

Public reports provided by the CSA also emphasize special missions conducted by RADARSAT-1 that include the imaging of over fifty climatically sensitive oceanic islands that according to

¹⁵⁵ www.space.gc.ca/asc/eng/csa_sectors/earth/earth.asp "Radarsat-1: About the Mission" [accessed April 2004]

CSA are often ignored in Global Earth System studies related to Global Change Research objectives, partly due to the small size of these islands and their remoteness. Another special background mission has been the imaging at 10 metre resolution of the world's major and capital cities, now concluded with data of over 170 cities. CSA has claimed that imagery of cities will be of primary use to urban planners and public utility operators. Often cited on CSA's own website, is RADARSAT's ability to produce near instantaneous "snapshots" of large areas, due to its independence from cloud cover or light conditions. CSA emphasizes the environmental applications for such sensor capabilities, noting the importance of these large mosaics for environmental change detection, regional-scale mapping, ice and ocean monitoring. CSA descriptions of RADARSAT capabilities and mission objectives contain large textual descriptions with some imagery that demonstrates the various technical capabilities of the sensor such as its many different beam-modes.

As a civilian satellite, RADARSAT-1 has addressed Canada's interest in supporting satellite remote sensing for resource management, environmental monitoring, maritime safety and economic development. These broad interests are extensively described by CSA on its website and in public reports while economic considerations are less prominent. Imagery and data products from RADARSAT-1 were made available to the international marketplace for limited cost-recovery reasons rather than through expectation that cost-recovery would be possible.

CSA information for the forthcoming RADARSAT-2 platform emphasizes the success of the original satellite while stating that the new satellite "will be used to understand, monitor, predict and protect the Earth and its environment."¹⁵⁶ CSA descriptions also note that the greater

¹⁵⁶ www.space.gc.ca/asc/eng/csa_sectors/earth/earth.asp csa.gc.ca "Radarsat-2 applications: new ways to see the world" [accessed April 2004]

flexibility and high-resolution capability of the new sensor will make it a major source of information for commercial applications. A detailed reading of recent CSA documentation reveals that commercialization is becoming a primary focus for the RADARSAT program. Discussion of commercialization plans for RADARSAT-2 is accompanied by increased reference to security, defence or sovereignty applications that is not evident in descriptions of the RADARSAT-1 program. Suggestions that marine surveillance will be a primary use for the new satellite are supported by several references to “monitoring for national sovereignty.” Program support by CSA to other federal departments such as DND for its Moving Object Recognition Experiment (MODEX) exemplifies an obvious shift towards including national sovereignty and military application needs.

References to surveillance applications for sovereignty and security become even more apparent when CSA annual reviews of the RADARSAT program in the late 1990’s are compared to more recent reports. In CSA’s 1998-1999 annual review, the follow-on system of RADARSAT-2 was described as allowing Canada “to continue fulfilling its unwavering commitment to protecting and monitoring the Earth’s precious resources and the environment.”¹⁵⁷ In more recent reports, the CSA has emphasized the versatility, high resolution capabilities and quick revisit times for the follow-on sensor, often linking these capabilities to its future projected commercial success. According to CSA, RADARSAT-2 will be able to acquire images at a spatial resolution of 3 meters and will provide the ability to detect “targets that are closely spaced ... thereby reducing ambiguities and increasing confidence in the data.”¹⁵⁸ While government documentation in the public domain does not directly discuss the military uses of hard-object recognition at high spatial resolutions, these capabilities nonetheless match closely with those required by military agencies

¹⁵⁷ CSA (1999a), p.1

¹⁵⁸ http://www.space.gc.ca/asc/eng/csa_sectors/earth/earth.asp “Radarsat-2 data products” [accessed April, 2004]

for target selection. The images accompanying the textual descriptions of RADARSAT-2's new capabilities relate further to military uses, and commercial forecasts by CSA suggest that commercial success for RADARSAT-2 will be dependent to a high degree on access to military and defence markets, most notably in the US.¹⁵⁹

5.2.2 Canada Centre for Remote Sensing (CCRS)

Public information describing the mission and applications for RADARSAT is also available from the Earth Sciences Sector of Natural Resources Canada (NRCan) and CCRS. Consistent with its organizational mandate, NRCan and CCRS emphasize RADARSAT applications that respond to climate change research, environmental and sustainable development initiatives nationally and internationally as well as lending support to other federal departments and agencies in developing their own capacity to use remote sensing technologies. CCRS has developed a series of individual research and technical programs comprised of industry, government and academic groups that undertake applications of remote sensing technology ranging from the community level to the continental scale including the (National) Atlas of Canada project.

CCRS has a mandate for receiving, processing and archiving EO data and for coordinating a national research program to develop and apply remote sensing technology to sustainable development and environmental protection. A description of program priorities that utilize RADARSAT imagery by CCRS does however reveal a focus on resource development rather than environmental conservation. The Northern Resources Development program for example is tasked with developing a geo-science knowledge base to stimulate private-sector investment in mineral and energy development and to create economic opportunities for northerners. The

¹⁵⁹ CSA (2003a), pp.32-63

program also supports capacity building in the north, particularly through increased employment opportunities provided by exploration companies.¹⁶⁰

The Earth Observation Data Services branch of CCRS describes its purpose as providing satellite data to NRCan and other government departments to support near-real-time applications such as forest-fire monitoring and mapping, natural hazards and ice monitoring as well as non-real-time applications such as sustainable development, including land use management and climate change. While outputs are described as supporting sustainable development initiatives and for reducing Canada's vulnerability to climate change, involvement of the private sector is a key element of the program as a means of creating global opportunities for Canadian geomatics companies. A subtle reference is therefore made to the commercial sovereignty aspects of the Canadian remote sensing sector, as government departments are tasked with "enhancing Canada's ability to leverage and participate in global advances, expertise and programs in support of Canadian needs."¹⁶¹

5.2.3 MacDonald Dettwiler (MDA) and Radarsat International (RSI)

In contrast to the standardized textual format of government websites, recently published MDA and RSI documents outlining RADARSAT capabilities and applications make much use of colour, processed and enhanced satellite imagery, and other visual tools describing an array of geospatial products and urging the viewer to "see the world differently" – RSI's corporate motto. MDA's commercial brochure entitled *Earth Observation Systems* provides a full colour LANDSAT-7 image of south-western British Columbia on its cover, engaging the viewer with rich green and swirling blue colours of islands and water. The document emphasises MDA's predominant position in supplying imagery and data from several commercial EO systems to the global market.

¹⁶⁰ http://ess.nrcan.gc.ca/pri/ndev_e.php#gm [accessed Oct. 28, 04]

¹⁶¹ http://ess.nrcan.gc.ca/pri/serv_e.php#eods [accessed May, 2004]

Specific applications are described under the heading “monitoring the planet” and list categories such as resource management and exploration, surveillance, and change detection. Accompanying the text is photography of ground station antenna and military hardware which contrasts with the visual messages conveyed by CSA, CCRS and pre-1999 RSI documentation which conveyed predominantly environmental and resource management themes. Applications of remote sensing imagery are further referred to by MDA on its website, where reference is made to security, natural resource and land management uses in this order. Besides one page devoted to EO in general, MDA provides an additional page devoted to describing satellite imagery applications for sovereignty and national defence.

In an RSI document published before the company was acquired by MDA, the RADARSAT sensor is introduced as “provid[ing] valuable information for use in environmental monitoring and natural resource management.”¹⁶² The document, titled *RADARSAT Illuminated*, is essentially a guide to RADARSAT-1’s products and services, tailored to both novice and advanced satellite imagery users. A close reading of the document reveals very few references made to sovereignty or surveillance activities for the RADARSAT-1 satellite. Images in the document provide a visual context to the application area or topic being discussed and generally display images of features such as river deltas, agricultural areas and coastlines. Several images highlight geological features, offshore oil operations, pipelines and ships in a number of countries. Other SAR images utilize false colour coding to highlight aquaculture, agriculture and changing land-use patterns in rural regions, representing RADARSAT’s application for issues of concern to developing countries such as food production and resource management.

¹⁶² RSI (1999), p.1

Application areas are listed as including agricultural monitoring, ocean features detection including coastline mapping and oil spill monitoring, forestry, geological mapping for terrain, petroleum exploration and oil seep detection and for wetlands mapping and watershed management. Base mapping applications include land use, land cover, topography and sea ice applications such as for ship routing. While a category of surveillance is listed in the document's preamble, a further description of this type of application is limited to terrestrial and maritime surveillance. The only mention of defence in the 113 page document is for credit given to DND for a 1997 image map provided of the Red River flood in Manitoba. No discussion of security or sovereignty applications of the RADARSAT sensor is provided or referred to in the document and no overt discussion is provided of the economic advantages of using RADARSAT data for resource development. From a close reading of this document which was prepared by RSI for a primarily civil-government sector clientele, a clear understanding of the 'public good' aspects of this technology is attained.

Specifically marketing imagery from the forthcoming RADARSAT-2 platform, MDA and RSI websites and documents surveyed between early-2003 and late-2004 describe applications and sensor capabilities in ways quite different than that observed in government documentation or RSI application guides prepared in the late 1990's. Under the heading of "monitoring agriculture worldwide," text on MDA's website declares that the "preparation of accurate estimates on crop production are essential in ensuring that the agri-business market is positioned to meet the demands imposed by the global population." Accompanying images show agricultural areas with a thick line drawn around one specific rectangular shape attached to a call-out box identifying the specific crop being grown at that location. Caption text claims that high resolution imagery is a valuable input to "precision farming techniques." Further expounding the merits of RADARSAT-2's multi-

polarization and high resolution capabilities, accompanying website text states that, “in many parts of Asia and Europe, where field sizes are small, the ability to produce high-resolution images will allow these markets to benefit.”¹⁶³

MDA’s commercial documentation also provides detailed descriptions of RADARSAT applications for disaster management including prevention, response and monitoring of flooding, oil spills, volcanic eruptions and severe storms. Using accompanying images of massive tropical storms, flooding, oil spills and a thermal plume from a nuclear plant, the “disaster management solutions” page emphasizes the quick response and high repeat coverage of the RADARSAT satellite system. Equal space on the MDA website is devoted to “mapping the world” and “object recognition” where ground-based photography of marine vessels are superimposed on satellite imagery of ships in a harbour. Text under the heading “operational surveillance” states that “RADARSAT-2 will allow government agencies to monitor key areas of interest, even when poor weather or darkness restricts the use of optical images.”¹⁶⁴ While the images and diagrams contained in the commercial documentation from MDA and RSI tend to place an emphasis on geometric shapes over biological parameters, an impression is also left on the viewer that access to satellite imagery is a necessary component of gaining technological or economic advantage over some form of adversary.

RADARSAT technology is also highlighted by MDA as a support tool for military initiatives, a category of application that was not presented in RSI’s *RADARSAT Illuminated* document of 1999. A press release linked to the MDA website describes how MDA expects to receive over \$3 million from several long-standing defence clients for RADARSAT-1 information:

¹⁶³ <http://radarsat.mda.ca> [accessed April, 2004]

¹⁶⁴ <http://radarsat.mda.ca>, [accessed April, 2004]

“RADARSAT-1 data supports several intelligence needs such as mapping and 3-D terrain modeling, target detection and change-in-activity monitoring.”¹⁶⁵ Another press release linked to the RSI website describes how RADARSAT-2 information will be evaluated by the US Air Force for “in-theatre support for the war fighter.”¹⁶⁶

While websites and commercial brochures offer some indication of the markets being pursued by commercial remote sensing operators, a review of RADARSAT-2’s commercialization plan reveals more specifically the strategic thinking that has gone into RSI’s marketing efforts. From the government sources of information on RADARSAT-1 that emphasized applications firmly in support of the ‘public good’, there is an emphasis on a wider range of applications and marketing approaches for RADARSAT-2 in the RSI’s 2004 document, *Turning the Scientifically Possible into the Operationally Practical: RADARSAT-2 Commercialization Plan* (Staples et al., 2004). Most notably, the document emphasizes a transition to information from data, recognizing a need to open-up new markets while continuing to meet the needs of existing RADARSAT clients. The document suggests that the technology-driven phase of development is being replaced by an exploitation phase where “economically useful” information needs to be provided.

In RSI’s commercialization strategy, it is clear that object recognition capability is a major priority, with an emphasis on increasing spatial resolutions so that “quantitative terrestrial information can be extracted.”¹⁶⁷ RSI also states unequivocally that the EO business will respond to a demand from those willing to pay for the products and services offered, stating that education and advertising provide only minor stimulation to the market. The unsurprising priority of RSI’s

¹⁶⁵ MDA press release “MDA Sees Continued RADARSAT-1 Defence Business” see www.mda.ca [accessed August 20, 2004]

¹⁶⁶ RSI press release “US Air Force to Test RADARSAT-2 Information Provision to War Fighters” see www.rsi.ca [accessed June 23, 2004]

¹⁶⁷ Staples et al. (2004), p.2

commercialization plan is that the products or services they provide must make an economic difference to the buyer, stating that “buyers won’t buy unless their ability to increase their market share in their business is improved, or their profitability or effectiveness of operations through efficiencies is enhanced by the products or services offered.”¹⁶⁸ From these statements, a theme emerges that places commercialization of RADARSAT-2 within the pattern of traditional economic analysis that measures growth and success according to market share and profitability with no reference to derived ‘common good’ aspects such as environmental protection or climate change monitoring that were clearly the focus of CSA and CCRS documents describing the RADARSAT program.

RSI’s commercialization plan states that “operationally and commercially viable solutions to current problems and issues related to the environment, security and commercial needs”¹⁶⁹ will all have to be developed in order for RSI to be successful in the competitive EO marketplace. While clear markets for surveillance, sovereignty, ‘security’ and the commercial resources sector are discussed, no reference is made to how environmental applications will achieve commercial viability, perhaps revealing the continuing need for government clients to alone apply EO to serve the needs of the public and sustainable environmental governance.

RSI’s commercialization plan recognizes a series of priorities for data and product supply, understanding the EO market to need better spatial resolution, reduced access times, increased revisit capacity and better reception ability by small antennae. While noting that the EO industry will respond to the needs of many actors including government, industry, military and environmental specialists, many of the criteria that RSI see as critical for RADARSAT-2

¹⁶⁸ Staples et al. (2004), p.3

¹⁶⁹ Ibid., p. 9

commercial success are aligned very well with military requirements, state sovereignty concerns and the needs of resource developers. In discussing the finer resolution capability of the forthcoming sensor, RSI clearly relates expected improvements in object detection and recognition to the creation of new defence, surveillance and sovereignty market sectors.

In a listing of features of RADARSAT-2 that augment those provided by RADARSAT-1, RSI's commercialization plan again identifies its priority for supplying military customers, noting that the new sensor will "enable a variety of new applications including defence surveillance and mapping...[and] better discrimination and recognition of objects on the ground."¹⁷⁰ Furthermore, the new sensor will provide a "greatly enhanced ability to rapidly program the satellite...to ensure RADARSAT-2 will be the system of choice for Defence and Emergency Management clients needing fast access to imagery"¹⁷¹ Discussions with RSI marketing staff also reveal that the physical surveillance market has become a key driver for the commercial EO industry since 9/11. While many capabilities exist for RADARSAT sensors to contribute to environmental governance as witnessed during a two-day course hosted by CSA on the applications potential of RADARSAT-2, the characteristics of the new sensor that most match those required by security and defence officials are those being stressed in marketing information, including fast access to data, high frequency of revisits, and guaranteed access to images anywhere in the world for mobile down-linking. In the case of environmental applications when they are mentioned, it is generally for such items as disaster relief, oil spill detection and other 'crisis' situations.

Pricing of RADARSAT data varies depending on the beam mode, corresponding swath width and the level of data processing requested. While comparisons between SAR imagery costs and

¹⁷⁰ Staples et al. (2004), pp.7-8

¹⁷¹ Ibid., p.9

optical imagery costs can be made, the different resolutions and spectral characteristics between the two make cost comparisons dependent upon intended uses of the data. For example, imagery costs per square kilometre are substantially less for RADARSAT than for optical satellite platforms, but scene sizes are larger. Prices range from US \$1.20 to US \$0.02 per km² although corresponding coverage areas equate these costs to about US \$3000 and slightly higher for practical purposes as satellite programming and processing fees will be added. Archived imagery of any scene is available for about US \$1500 which, considering the area covered, is substantially cheaper than optical imagery available for a much smaller field of view as will be seen in the following sections. Customers can order imagery from RSI's international network of more than 80 distributors, ten of whom operate their own ground receiving stations.

RSI and MDA websites do employ eye-catching imagery to engage the viewer, but no sample imagery archive is made available and no single theme emerges in terms of the selection of imagery portrayed on the websites. Contrasting with the review of websites from other commercial satellite companies provided below, RSI displays less immediately recognizable Earth imagery, instead placing imagery examples and client testimonials into applications categories ranging from agriculture and environment to oil pollution and ship detection. A wide selection of other commercial satellite imagery is also made available by RSI, revealing its large number of foreign partnerships and its position in the global remote sensing market.

5.3 Analysis of Commercial EO Ventures in the United States

The US government has been the leading provider and user of satellite imagery data for over 40 years, but this has recently started to change as several companies have begun to acquire and launch privately owned EO satellite systems. Stemming from the passing of the *Land Remote*

Sensing Policy Act, the US Department of Commerce has awarded 21 satellite operating licenses to 15 separate companies since 1993.¹⁷² The ventures and marketing approaches of three prominent US commercial remote sensing satellite firms are discussed below.

5.3.1 DigitalGlobe / QuickBird

Colorado-based DigitalGlobe (formally WorldView Imaging Corporation) was the first company to receive US government licensing approval for its commercial remote sensing satellite plans in 1993. An initial in-orbit failure of its 1997 EarlyBird satellite was a major setback, as was a 2000 launch failure of its first QuickBird satellite. DigitalGlobe has been operating the second QuickBird satellite (officially QuickBird-2) since its successful launch in 2001. This commercial remote sensing platform provides 2.8-meter multi-spectral imagery and a maximum resolution of 0.6-metres in the panchromatic mode, which is currently the highest resolution available commercially. Additionally, the satellite sensors provide the largest commercially available swath width at high resolution, making it a very flexible tool for information collection. The sensor operates in the optical and near infra-red spectrum, thus requiring cloud-free conditions for unrestricted image acquisition. The operations of the QuickBird satellite are centralized in the US with on-board solid-state recorders serving to store digital images until a downlink can be established primarily over the US continent.

In analysing the marketing approach and targeted user group envisioned by the DigitalGlobe EO venture, the overall impression gained from a thorough review of all official Internet sources is that QuickBird primarily serves resource managers such as farmers and forestry companies. DigitalGlobe describes itself as a company founded by GIS and mapping users with both its investment and marketing partners indicating a predominant interest in civilian and environmental

¹⁷² <http://www.licensing.noaa.gov/licensees.html> [Nov. 5, 04]

applications. From the ‘Applications Overview’ section of its website: “DigitalGlobe is changing the way our Earth’s resources can be managed and sustained by improving the way information about our planet is collected, packaged and distributed.” Applications are “tailored to industry users seeking accurate, high-resolution, multi-spectral imagery to assess, observe, monitor and anticipate changes in their surroundings.”

Prominently highlighted on DigitalGlobe’s website are product sheets on ‘Effective Forestry Ecosystem Management’ and ‘Agrowatch’, two applications devoted to forest and agricultural resource mapping, change detection and management. Each application brochure is accompanied by colourful photography of green tropical rainforests and lush, productive fields being worked by hand. A conceptual link is established between the satellite imagery obtained from above, and results on the ground that ultimately link to the notion of profitability. Agrowatch is described as “help[ing] growers and consultants make faster, better informed and more accurate crop management decisions, resulting in greater productivity and higher revenues.” Each highlighted product is designed for the non-technical user, with commentaries provided by users such as: “you can see what is going on in areas you can’t access” and various other references to cost savings and productivity improvements.

While there is no substantial imagery on DigitalGlobe’s website suggesting that QuickBird products are marketed to military and intelligence organizations, corporate documents do reveal that Northrop Grumman, a corporation focused on mission planning for US tactical military aircraft, provided the technological infrastructure for the QuickBird satellite, revealing the reliance on military-sector knowledge required for this program. Slightly ambiguous statements found on product guides describing QuickBird as providing applications for users seeking to “capitalize on

the power provided by spatial data” suggest that ‘common-good’ uses are only part of QuickBird’s market, although these are reflected dominantly in DigitalGlobe’s public marketing documentation.

Companies such as DigitalGlobe clearly make extensive use of the visual appeal of satellite Earth imagery and web-based technologies. A banner image is updated daily on the website masthead, with prominent regions of the website devoted to ‘sample images’ and ‘images for the media’. A call-out text box describes recent uses of QuickBird imagery as highlighted in the public media: “DigitalGlobe satellite imagery helps Alaska inventory forest health”, connecting the company profile with a sentiment that the public interest is being pursued. Other striking features of the website include offers for “posters of your home.” Website viewers are invited to “download imagery to your desktop” or “fly around the world.” The colourful use of imagery on the DigitalGlobe website and in its marketing brochures has the effect of drawing the viewer in, providing them with the up-to-the-minute knowledge required in a fast-paced information-based society. An almost ‘peeping Tom’ perspective is gained from being provided with casual views of very high resolution images of cityscapes that show cars, boats, houses and their backyard pools in true colour with excellent clarity.

QuickBird satellite imagery is seen to be very responsive to current world events, placing the website viewer in visual contact with any number of critical issues. Out of 65 sample images available for free download, several recent or pending natural disasters were highlighted including hurricanes in the Gulf of Mexico, volcanic eruptions in Italy and Oregon, forest fires in Arizona and flooding in Haiti. Other images highlighted cities and urban scenes where major cultural events recently occurred including tent cities formed by annual spiritual pilgrimages in the Middle

East, the Olympics in Athens, D-Day in Normandy and Memorial Day in Washington DC.

Political events were also given prominence by images of Ground Zero in New York (following 9/11), Madrid (following terrorist bombings), Fallujah (following major military battles in Iraq), Tehran and the Natanz nuclear facility (following debate over Iran's nuclear program), and Yongchon (following North Korea's withdrawal from the nuclear Non-Proliferation Treaty). The remainder of the images provided as samples of QuickBird's capabilities were of prominent American or world cultural icons such as the Statue of Liberty, US sport stadiums and the Eiffel Tower. Of all sample images, only a very few corresponded to the predominant textual messages being conveyed by public documents, that DigitalGlobe's focus was on environmental and resource governance issues.

The visual and cognitive impact of satellite imagery is perhaps best capitalized on the DigitalGlobe website with the use of such tools as the ImageLibrary which allows users to tour available imagery of the world commencing with a global map. The user can zoom and pan into their desired location and available imagery is displayed. While substantially downgraded, the user is provided with an on-line photographic atlas of many geographic regions. With this tool and the use of sample imagery, a user can literally be provided with a 'birds-eye view' of dramatic landscapes, given without context. Although much of the pre-prepared sample imagery is of urban landscapes, familiar scenes or current world events, the ImageLibrary provides access to scenes that are the user's choice, conveying a sense of empowerment to the viewer. In Monrovia, Liberia, a scene can be found that places the opulent-looking US Embassy and Presidential Palace buildings in a stark contrast to the corrugated steel roofs of adjacent urban dwellings. But such scenes do not connect the viewer to these details unless they are being sought. Disaster scenes such as floods and forest fires although devastating in an ecological or humanitarian context are

eye-catching and subtly beautiful when provided without a context. Images of the Three Gorges Dam in Hubei Province, China do not begin to indicate the ecological disruptions associated with this massive project which, to the untrained eye, appears as a marvellous feat of engineering.

DigitalGlobe's marketing strategy consists of providing non-exclusive contracts on a "One World - One Price" policy. Various subscription options can be purchased by users wishing to schedule regular revisits and imagery updates at volume-discounts. All satellite image acquisitions are placed in the ImageLibrary so that other users can access available imagery. This practice is consistent with US government policy that restricts the release of imagery within 24 hours of collection to "allow US armed forces to exercise standard operational security." However, for an additional charge, DigitalGlobe clients can delay the placement of their satellite-tasked imagery acquisitions into the ImageLibrary for renewable periods of six or twelve months, an appropriate option, according to DigitalGlobe, for those wishing their area of interest to remain confidential from the public, the media or competitors.

Prices for imagery vary depending on whether it is being purchased from the ImageLibrary or by tasking the satellite, and depending on the level of image enhancement performed on the collected data. As a rough baseline, standard tasking of the satellite will cost anywhere from US \$1,600 to US \$9,250 per scene (\$6 to \$32 per km²) with the scene size defined by the swath width and angle of the satellite sensor to the desired image target. At nadir (satellite directly overhead), QuickBird provides a maximum 16.5 km swath width and therefore a 272.25 km² potential ground coverage area. This maximum coverage was used to arrive at the baseline imagery costs for QuickBird, with the cost range defined on the level of desired processing, from basic imagery to orthorectified and geocoded data scaled to the US Geological Survey's Digital Ortho Quarter

Quadrangle (DOQQ) tiling system.¹⁷³ A standard DOQQ image costs US \$576 whether tasked by the satellite or retrieved from the ImageLibrary. Interestingly, costs for imagery from the ImageLibrary can range from US \$5,000 to US \$13,000 per scene. Costs can also increase or decrease depending on the priority of the order and the level of cloud-free coverage in the final product. To delay the imagery from going into the ImageLibrary, users can pay an extra US \$3,000 for each six-month delay.

As noted earlier, costs can be substantially reduced by repeat-users of imagery through subscriptions for regular updates of an area of interest. DigitalGlobe clearly attempts to be flexible but also rigorous in its pricing policies, offering no discounts to educational institutions, developing countries or NGOs although various types of licenses are offered to commercial, civil government, non-US organisations and educational institutions in recognition of their differing data-sharing needs. Repeated references are made to the suggested users of QuickBird products, highlighted in the 'Online Image Atlas' product which claims to provide the world's largest image library: "users can log in and locate properties and neighbourhoods, interact with images by panning and zooming, and cut/paste, download or print images." The application is suggested as ideal for real estate firms, insurance companies, public safety agencies, banking and engineering firms, utilities, oil, gas and telephone companies, and federal, state and local agencies. Obvious by its absence due to the apparent market-focus on environment and resource management issues found in DigitalGlobe's documents, is any attention given to the needs of the global community or developing countries for applications associated with sustainable resource governance. The publicly available marketing information similarly does not exclusively highlight military or

¹⁷³ A Quarter Quad tile is defined as 3.75 minutes of latitude by 3.75 minutes of longitude, equating to an approximate ground area of 42 square kilometres (15 square miles), latitude dependant.

intelligence uses of QuickBird imagery products, leaving a level of ambiguity commensurate with a private corporation that values all paying customers equally.

Looking forward, DigitalGlobe's key markets are identified on its website as coming from both civilian and intelligence organisations, citing 10-year industry forecasts that predict substantial positive growth for the EO satellite sector. For its even higher resolution follow-on system, WorldView, planned for deployment in 2006, DigitalGlobe's website notes how the US National Geospatial-Intelligence Agency (NGA) has provided US \$500 million of funding indicating the influence of strong commercial subsidies from the US intelligence community. While DigitalGlobe product sheets and marketing information does not immediately reveal its dependence on government contracts, this situation becomes clear when a closer-reading of available financial statements is undertaken. As such, DigitalGlobe conforms to the established trend that sees commercial EO firms struggling to create substantial non-government markets for satellite imagery. In a discussion of future commercial trends for the QuickBird satellite program, DigitalGlobe experts suggest that software applications and value-added products must continue to develop to serve markets that have been traditionally underserved. In addition, DigitalGlobe states its acute awareness that US government funding commitments are important drivers for its future business plans, applications development priorities and design plans for follow-on remote sensing systems.

5.3.2 Orbital Imaging Corporation (OrbImage) / OrbView

Dulles, Virginia-based Orbital Imaging Corporation (OrbImage) operates two commercial remote sensing platforms including the OrbView-2 ocean and land multi-spectral imaging satellite launched in 1997 (also known as SeaStar/SeaWiFs) and OrbView-3, a commercial high-

resolution satellite launched in 2003 that is similar to DigitalGlobe's QuickBird in spectral and resolution characteristics although the swath width of the sensor is limited to 8-kilometres, approximately half of that available from QuickBird. An OrbView-4 satellite was intended to carry a hyper-spectral sensor funded by the US Air Force Warfighter program but was lost in a launch failure in 2001. OrbImage markets 1-metre panchromatic and 4-meter multi-spectral imagery from its own high resolution satellite and also acts as a distributor for imagery from Canada's RADARSAT program. OrbImage claims that its own imagery can be made available in real-time using an Internet connection and prides itself on both its ability to provide timely imagery and its enhanced image processing services.

The OrbView-2 satellite, which carries the SeaWiFS sensor, provides 1 km resolution data in 8 spectral bands and according to OrbImage, "is the world's first commercial satellite to image the Earth's oceans and land surfaces in color on a daily basis" facilitating NASA, the satellite's anchor customer, with valuable data for studying global warming. Non-scientific applications for OrbView-2 data include commercial fishing, environmental monitoring, and military uses according to OrbImage. Of note, the "SeaStar" fishing service supports upwards of 100 operational fishing vessels in detecting fish stocks.

The OrbImage corporate image is immediately differentiated from other private satellite operators by its direct recognition of a strong client-services relationship with the US intelligence community. A corporate profile provided on the OrbImage website lists applications for its high resolution satellite as including construction planning, retail site selection, high-resolution mapping, agriculture and forestry management, treaty monitoring and environmental management.

In a description of the OrbView-3 sensor capabilities, a reader is provided with a sense of the utility and intended applications of the imagery:

One-meter imagery enables the viewing of houses, automobiles and aircraft, and makes it possible to create highly precise digital maps and three-dimensional fly-through scenes. Four-meter multispectral imagery provides color and infrared information to further characterize cities, rural areas and undeveloped land from space.

OrbImage marketing documents indicate a focus on four market segments including: mapping and surveying for telecommunications, construction, transportation, utilities and government users; a natural resources segment including oil and gas exploration, large-scale farming and fishing, forestry management, natural disaster assessment and other environmental monitoring applications; consumer applications including real estate assessment, travel planning, news event coverage and other popular media uses such as 3D simulations for video games; and national security, primarily for supplementing US intelligence and defence requirements but also for supporting allied foreign government agencies.

These four market-segments are further described and explored on OrbImage's website through a 3-way categorization of imagery applications including "Environmental, Commercial and National Security." For environmental applications, the OrbView-2 satellite is tasked primarily with civilian and environmental applications including "the monitoring [of] subtle changes in the health of land and ocean regions" and "measuring phytoplankton and sediment concentration in oceans and lakes," useful for coastal pollution monitoring and red-tide tracking.¹⁷⁴ For OrbView-3, the rapid re-visit capability is highlighted as useful for emergency response, disaster relief and for "assessing the damage from natural disasters such as floods, forest fires, earthquakes and severe storms" or for "evaluating the environmental impact of industrial activities such as

¹⁷⁴ <http://www.orbimage.com/appl/envir/monitor.html> [Oct. 22, 04]

mining.” A featured partner of OrbImage for environmental applications is the Global Environment & Technology Foundation, a US not-for-profit organization that “helps create the infrastructure necessary to achieve sustainable development.”

For commercial applications, OrbImage lists “new development permitting, construction planning, environmental impact assessment, utility infrastructure planning and wireless telecommunications design” as some of its key markets. Imagery accompanying claims of OrbView-3’s utility for urban applications portrays complex overlays of satellite imagery, road networks and land-use categories, with various examples provided where imagery enhances visual appeal and is complementary in providing a visual grounding for other geographic information on digital maps. An extensive listing of other commercial applications includes uses in the construction industry, state and local governments, telecom, oil and gas companies and fisheries. A well-marketed application for the OrbView-2 satellite is the “SeaStar Service” which “has enabled tuna purse seine and long line vessels worldwide to find good fishing locations faster, reducing fuel costs in the process.” Speaking to the cognitive aspects of geographic and spatial information, “intuitive interfaces... allow captains and fleet managers to easily translate advanced satellite data into successful fishing decisions.” Other emerging consumer markets for OrbImage products are seen to include satellite imagery for travel planning “enabling travelers to visualize their destination before their arrival... [also] facilitating more direct travel routes.”

In terms of providing services to the US Intelligence community, OrbImage states that “OrbView-3 high-resolution imagery will help the United States government to monitor borders; gather intelligence on potential conflicts; identify and target enemy troops and assets; plan air, ground and naval missions; deploy resources; and assess battle damage.” Accompanying visuals consist

of a striking comparison between military targets before and after strike, unabashedly indicating the use of OrbImage's products in US military operations.

Twice in 2004, OrbImage was awarded contracts to supply the NGA with imagery and value-added products from its satellites. OrbImage is in a similar position to DigitalGlobe with respect to its future relationship with the US Intelligence community having recently announced that it will also partner with the NGA under a parallel US \$500 million contract that "will provide OrbImage with both long-term revenue commitments as well as capital for the development of OrbView-5, OrbImage's next-generation high-resolution imaging satellite."¹⁷⁵ Similar to the contract signed with DigitalGlobe, this contract will assure the NGA greater access and priority to high-resolution commercial satellite imagery. In OrbImage's 2004 second quarter financial statement, it stated unequivocally that: "We depend on contracts with government agencies for a substantial portion of our revenues." Government contracts accounted for over 50% of OrbImage revenues between 2003 and 2004, and as these agencies can terminate or suspend their contracts at any time, with or without cause according to OrbImage, any change in policy, priorities or funding levels by the US government could severely harm its business or even its viability as a private EO operator.¹⁷⁶

Of relevance to a discussion of the OrbImage corporation and its satellite remote sensing applications potential is the activities of its parent company, Orbital Science Corporation, founded in 1982 with the goal of "making space technology more affordable, accessible and useful to millions of people on Earth." Since then Orbital Science has grown to become the world's leading

¹⁷⁵ http://www10.giscale.com/nbc/articles/view_article.php?section=CorpNews&articleid=145377 [Oct. 22, 04]

¹⁷⁶ OrbImage Inc. Quarterly Report for the six months ended June 30, 2004

developer and manufacturer of small satellite and launch systems. Orbital Science is also a primary contractor of the US military as described on its website:

Orbital provides a complete set of reliable, cost-effective products... from low Earth orbit (LEO) spacecraft that perform remote sensing and scientific research... to lightweight launch vehicles that transport satellites into orbit, target rockets used to test missile defense systems, and interceptor booster vehicles that are deployed to protect against enemy missile attack.

In 2003, Orbital Sciences reported that half of its revenues came from defence and intelligence agencies, with 26% going to missile defence interceptors and 13% going to target vehicles and missiles. Its technologies and products have “become the building blocks of space-related systems used ... to defend [the US], to provide global communications, to study the Earth, and to explore [the] solar system”¹⁷⁷ signifying its firm position as a stakeholder in all aspects of space development.

Prices for OrbView-3 imagery are not listed in great detail on the OrbImage website, primarily as a result of the claim that OrbImage “distributes its products directly to the US government for national security applications.” Imagery of cities is made available from the OrbView archive at costs comparable to those from DigitalGlobe on a cost per area basis. For imagery requests that are not available through the archive, and for image processing needs, users are instructed to contact the company directly, or contact a regional reseller. Making direct comparisons is difficult due to the different products being offered, but an OrbView-3 image corresponding to a DOQQ of available archived imagery of cities will cost about US \$350 compared to a slightly more expensive QuickBird DOQQ at US \$576 which can come from either the ImageLibrary or from satellite-tasking.

¹⁷⁷ <http://www.orbital.com> [accessed Nov. 4, 04]

OrbImage acts as a reseller for imagery from Canada's RADARSAT platform out of recognition of the limitations of optical imagery in locations of heavy cloud cover. In contrast to RSI's own descriptions, radar imagery is described by OrbImage as useful for "general mapping in persistently cloudy regions, near real-time surveillance, direct exploration of offshore oil reserves and monitoring of ice flows for safe ship routing."

OrbImage states that access to its data is available through its own Internet site and also through an extensive network of distributors and value-added resellers, including through direct 'real-time' download to ground station operators located around the world. Orbital Imaging maintains the satellite, programs the sensors for image acquisitions and archives digital copies of all imagery consistent with government policy. In contrast to other platforms, OrbView tasking requests can be assembled by OrbImage partners who can then collect data over a given region for their exclusive use, with copies provided back to Orbital Imaging for archiving. The regional jurisdictions for exclusive data contracts can be as large as a ground station footprint or imagery 'cone' or be tailored to match the political boundaries of a given state. Customers can also lock into exclusive regional agreements with OrbImage, securing access to imagery while denying others access. It is even directly suggested on OrbImage's website that a state could use OrbView satellites to image itself through an exclusive territorial agreement, and thereby deny surveillance abilities to its neighbours.

From the preceding analysis of OrbImage marketing information, product descriptions and applications development priorities, it is evident that an economic imperative to stay afloat as a viable EO venture is the driving force behind the business plan. Having emerged from bankruptcy protection at the beginning of 2004, OrbImage is a corporation that will, like most

others, make bottom-line decisions on economic factors, increasingly attempting to market data and value-added products to a growing global marketplace, irrespective of intended use. No overt mention is made anywhere in OrbImage's marketing and product brochures that 'public good' outcomes need to be assessed in balance with private interests. Having a two-satellite system, one supplying primarily civilian customers such as NASA and one supplying primarily private-sector and national intelligence and defence agency needs allows OrbImage to pursue a de-facto balance between 'public good' applications and those in the private and sovereignty sectors.

5.3.3 Space Imaging / IKONOS

Colorado-based Space Imaging was founded in 1994 through multiple private-sector investors. Space Imaging became the first company to successfully launch a commercial remote sensing satellite when it deployed IKONOS in 1999.¹⁷⁸ IKONOS sensors provide 1-metre and 4-metre pixel resolutions in panchromatic and multi-spectral modes, respectively. In its marketing brochures and on its website, Space Imaging describes itself as a full geo-spatial services company, with a mandate "to meticulously document the ever-changing features of our environment, our resources, and our world." On average, IKONOS claims to collect about 900 images per day.¹⁷⁹ In establishing its prominent place in the commercial EO market, Space Imaging acquired, in 1996, the Earth Observation Satellite Company (EOSAT) that had 10 years earlier been granted exclusive rights to market data and collect foreign ground station fees from the US Landsat system.

¹⁷⁸ Space Imaging's first attempt to launch its IKONOS-1 satellite failed in April 1999 but a second successful attempt of IKONOS-2 was made in September the same year.

¹⁷⁹ Space Imaging press release, 17 Dec. 2001, "Space Imaging Names 2001 Top 10 Images Taken by the IKONOS satellite"

Operation of IKONOS is delegated by Space Imaging to regional affiliates run by foreign firms or government agencies with their own ground station capabilities. Internationally, Space Imaging sells time to its partners on the IKONOS satellite, with regional affiliates producing products to suit their own needs. Space Imaging also sells equipment for image processing, analysis and mapping. Use of affiliates by Space Imaging is a strategy envisaged to provide greater autonomy to international users than with other systems by allowing these exclusive users to control sensor tasking, data reception, distribution and archiving. Affiliates also have the ability to directly upload imagery acquisition schedules to the satellite, with overall executive control remaining with Space Imaging.

An analysis of product guides and applications descriptions for IKONOS and a detailed reading of corporate profiles and marketing objectives for Space Imaging reveal the company's own interest in providing value-added services, with regional affiliates left to manage their own needs for imagery. Pre-processed, enhanced imagery is the focus of Space Imaging's outward marketing of IKONOS and an impressive use of interactive visual information products is provided on its website. Imagery is marketed through Space Imaging's Carterra web server and its many resellers, while products such as 'posters from space' are highlighted on the main Space Imaging website. To augment its own visible-spectrum sensor, Space Imaging also incorporates remote sensing satellite data from India's IRS platform, Landsat and RADARSAT into its product line, acting as a value-added reseller for each of these platforms.

Four key market and application sectors for IKONOS are described as forestry, fire and ecosystems; national security; airports and harbours; and local and regional governments. Other applications are described for agricultural monitoring, disaster assessment, environmental

planning, oil and gas exploration, insurance and risk management, mapping, telecommunications and utilities planning, real estate development, entertainment and media. Also highlighted by Space Imaging's product brochures are its own decision-support tools for a variety of business, economic, environmental and 'security' applications. Space Imaging claims to "bring actionable Earth imagery to life, revolutionizing the way we view, map, measure, monitor and manage the world in which we live."

In terms of the balance portrayed between public-good applications and those directed to private firms and military organizations, IKONOS appears at first to be evenly supplying decision-makers in environmental management roles and in homeland security organizations. A closer reading of the many highlighted application areas for IKONOS reveals however, that most environmental management applications are generally associated with private firms looking to gain economic advantage by utilizing automated terrain and resource modelling systems or route planning algorithms in the agriculture, forestry, insurance, telecommunications and transport industries. A significant case study is provided for irrigated landscape mapping that highlights the need for human behaviour to be reformed to conserve water use in many US states. The innovative 'Geobook' application provides stand-alone or web-based summaries of critical infrastructure in the US in a digital book format.

The 'Homeland Security' section of Space Imaging's website is devoted to remote sensing tools that assist in "monitoring, planning and preparing for disasters and emergencies" and for responding to "natural, terrorist and unintentional events." Major Space Imaging partners include Lockheed Martin and Raytheon, two primary military contractors in the US that place Space Imaging in the envelope of activities associated with the US defence industry. Space Imaging

claims that its “products are ideal for visual and interpretive applications such as intelligence or visualization that do not require high positional accuracy” and that “army locations can be tasked from satellite in 1-meter detail to plan effective defense tactics.” One of Space Imaging’s regional affiliates emphasizes the military uses of IKONOS imagery by describing how the ‘Open Skies’ principle allows defence authorities to access high resolution imagery of any area in the world.

SIME, Space Imaging’s Middle East affiliate states that:

Based on the information provided by the satellite imagery, intelligence can feed the defense authorities with the necessary information to plan locations of troops on the borders properly, determine sites to display security forces in the field and determine the security instruments and tools to be placed in these areas.¹⁸⁰

SIME and other affiliates further describe their services to intelligence and security clients as facilitating battlefield surveillance, order of battle, camouflage, concealment and deception, targeting and bomb damage assessment. Use of IKONOS imagery is highlighted for managing ‘security’ issues of all kinds including narcotics, organized crime, critical facilities protection and selection of patrol points. Elevation models derived from imagery are even highlighted for their use in determining possible sniper locations on buildings.

Perhaps more than other commercial high resolution satellites, IKONOS is known for its association with military agencies, particularly with respect to exclusive contracting arrangements provided to the US Department of State during military operations in Afghanistan and Iraq following 9/11, a fact highlighted on Space Imaging’s website. In October 2001, a large number of academic and popular media reports discussed the exclusive provision of IKONOS imagery to the US defence and intelligence community and concluded that while providing some useful imagery, the tactic was primarily used as a means of denying IKONOS imagery to other potential

¹⁸⁰ <http://www.spaceimagingme.com> [Oct. 28, 04]

users.¹⁸¹ The exclusive contracting arrangement avoided claims that government shutter control denies First Amendment rights to US citizens for freedom of expression and freedom from government interference. During the Afghanistan and Iraq wars, Space Imaging described the use of IKONOS imagery as supporting intelligence activities, military planning and operations, damage assessments, public diplomacy and humanitarian assistance, which attempts to portray the use of its imagery as a general public good. Media reports and DoD documents clearly reveal however that IKONOS imagery was also used to define deployment locations for missile and air defences and to support mission planning including bombing campaigns.¹⁸²

Prices for IKONOS imagery are described on the Space Imaging website. Through the Carterra application, users can directly order, purchase and download data on-line if it is available in the archive. Imagery of cities, similar to that available from OrbImage is available at comparable costs. In contrast to DigitalGlobe's 'One World, One Price' policy however, prices for IKONOS will vary by location, data owner and imagery date as Space Imaging's regional affiliates set the pricing. Under this arrangement, a user can expect to pay anywhere from US \$7 per km² for imagery of North America to US \$39 per km² of Europe, Africa, Asia and the Middle East and as much as US \$56 km² for Japan. Again, direct cost comparisons are difficult to make due to product differences, but an archived image which needs to be purchased over a minimum continuous area of 49 km² according to Space Imaging, can range from about US \$350 for North America to over US \$2000 for Japan. For a tasked satellite acquisition, a minimum of 100 km² must be ordered, with costs ranging from US \$700 for North America to US \$5600 for Japan.

¹⁸¹ Michael R. Gordon "Pentagon Corners Output of Satellite Images of Afghanistan" *The New York Times*, (Oct. 19, 2001); Duncan Campbell "US Buys Up All Satellite War Images" *The Guardian* (October 17, 2001); Janet Forgive "US Buys Rights to Satellite Photos" *Rocky Mountain News*, (Oct.16, 2001)

¹⁸² Livingston et al. (2002), Op. Cit.

Costs for an equivalent DOQQ of available archived imagery of cities are consistent with those obtained from DigitalGlobe and OrbImage satellites.

Space Imaging's order process has been described by some reviewers as "distressingly opaque"¹⁸³ providing essentially no insight into the status of a collection request between the time the order is confirmed and the time the image arrives via courier. Anecdotal evidence suggests that some priority in collection is given to larger customers, although the extent and impact of this prioritization on smaller customers is unknown. The simple expectation that Space Imaging would regard each request for collection of a scene with equal priority, much as a national mail service gives equal priority to all packages, seems without foundation.

The use of imagery on the Space Imaging website and the sites of its affiliates is by far the most sophisticated of all the reviewed on-line materials. Similar associations are made between environmental applications of satellite imagery and 'green' images, and defence or military applications with seemingly strategic images of harbours, military bases or airports. What Space Imaging's site does do is describe in greater detail the future capacities for its applications such as on-line tools and the Geobook which can stand alone or be web-enabled, providing users with a combination of satellite imagery, GIS, photos, diagrams, maps and text that readily enables visualization of features on the ground. Another example of the integration capacity of satellite imagery and ground-based applications is the water-budget example provided by Space Imaging's Irrigated Landscape Mapping project. In this example, individual land-use patterns and irrigation needs can be linked to water metering at individual residences or businesses, with performance indicators provided to on-line users. The video-like zoom and pan tools provided on the Space

¹⁸³ <http://www.globalsecurity.org/eye/lessons.htm> [accessed Nov. 22, 04]

Imaging website similarly provides casual users with various ‘gee-whiz’ features that thoroughly capitalize on the visual sensory organ.

Much like the web-based marketing tools used by the other US satellite imagery providers, IKONOS imagery of recognizable geographic locations is highlighted throughout Space Imaging’s website. Images of sports stadiums, racetracks, universities, golf courses and cities are offered for sale as posters ranging from \$15 to \$35 appealing to a wider non-technical market. Well known geographic features ranging from Ayers Rock to Mt. Everest to Pearl Harbour are shown prominently in the imagery samples pages. An emphasis on strategic locations of interest to the US military and to current world events is also noticeable with images portraying burning oil installations and recent bombing sites in Iraq. Along with a thorough listing of media citations that have utilized IKONOS imagery, the viewer is drawn to the notion that satellite imagery is growingly part of a complete media package that enables a mastering of a particular location from above.

5.4 Analysis of Official Policies Governing the Earth Observation Industry

Countries with active EO industries have been compelled to devise regulatory mechanisms to control the operation of dual-use satellite systems to protect sovereign interests, and balance public and private needs. The primary thrust of these policy efforts has resulted from a need to better position national EO industries for success in a highly competitive global marketplace. In addition, policies have been designed to maintain control over foreign access to data and technology, and for data standards, distribution and pricing issues to be addressed through regulatory frameworks.

The following offers an analysis of policies governing EO in both Canada and the US. As will be seen, policies have been generally responsive to step changes in technology, and have been shaped by a diversity of factors such as how programs are funded, the interests being served by the proponents of projects, a state's perception of its 'security' issues, and to a certain extent by existing international norms.

5.4.1 Canadian Remote Sensing Space Systems Policy

In Canada, a formal policy governing remote sensing space systems is at an advanced stage of preparation.¹⁸⁴ In 1999, the Canadian Government announced that as the ownership of remote sensing satellites moves from the public to the private sector, new legislation would be developed to regulate this industry. The stated purpose of the legislation at the time was to "protect national security, help safeguard human lives and enhance Canadian competitiveness in the growing space sector."¹⁸⁵ In 2000, Canada entered into the *Canada-United States Agreement Concerning the Operation of Commercial Remote Sensing Satellite Systems* in an attempt to harmonize Canadian policy approaches with existing US laws and regulations. Since then, the CSA (2002) reported that the need for legislation governing the remote sensing industry was prompted by US concerns over the higher resolution capacity for RADARSAT-1's follow-on system:

When it became apparent that Canada's RADARSAT-2 would have a quite capable 3 meter resolution in fine mode (compared to RADARSAT-1's 8 meter resolution), the US requested the conclusion of an access control agreement with the Government of Canada, which agreement was signed in 1999.¹⁸⁶

Public documents highlighting the main issues that Canada's new legislation proposes to address is analysed in the following section along with a textual analysis of Bill C-25, "*An Act governing*

¹⁸⁴ Bill C-25, "An Act governing the operation of remote sensing space systems" was tabled in the House of Commons on Nov. 23, 2004 for first reading.

¹⁸⁵ DFAIT news release 134 (June 9, 1999) "Canada to Control Imaging Satellites" www.dfait-maeci.gc.ca [accessed June 4, 2004]

¹⁸⁶ CSA (2003a), p.59

the operation of remote sensing space systems.” The background document titled *Developing a Canadian Access Control Policy for Commercial Remote Sensing Satellites* (DFAIT, 1999) and associated press releases and policy backgrounders also provide insight into how Canada proposes to balance its sovereign concerns with the issues of economic competitiveness and the provision of public goods from Canadian remote sensing systems.

Canada’s international prominence in remote sensing is highlighted in the 1999 policy backgrounder and again in briefings accompanying the introduction of Bill C-25, including references made to how Canada is a world leader in the design, construction and operation of high-performance civilian satellites and sensors. Three main use areas are highlighted for EO data in Canada, including: cartography; land use and natural resources management; and reconnaissance and surveillance. Each use area is then further described in terms of the advantages that EO data provide to industries such as farming and forestry and for locating mineral, oil and gas deposits.

From the press release that prefaced the 1999 background policy document, the initiative to create the new legislation came from a need to “maintain and protect Canada’s critical industrial base, to further advance the technology, to create economic opportunities and to promote regional stability together with the private sector.”¹⁸⁷ Prominent in the first few paragraphs of the 1999 policy backgrounder is the sense that protecting and furthering Canadian economic interests – primarily related to the exploitation and transportation of natural resources – is the driving factor behind the government’s need for shutter control provisions:

Decision makers in Canadian companies are demanding better quality data to generate greater economic opportunity in various fields, including ice reconnaissance, coastal

¹⁸⁷ DFAIT press release 134 (June 9, 1999) “Canada to Control Imaging Satellites” www.dfait-maeci.gc.ca [accessed June 4, 2004]

surveillance, oceanography, cartography, geology, environmental monitoring, hydrology, agriculture, forestry, and disaster response and mitigation.¹⁸⁸

Overriding the perceived economic imperatives of the forthcoming policy, the document also states unequivocally that other vital national interests will be served. The policy backgrounder states that “[t]he Government of Canada will develop its policy to preserve government controls on data acquisition and dissemination in urgent and critical temporary situations.”¹⁸⁹

Canada’s long-standing commitment to international cooperation in peaceful space development is also highlighted, contextualized by the notion that “collective security agreements” oblige Canada to protect the security of its allies who are taking similar measures to control satellites under their jurisdictions, clearly referring to US policy efforts. The policy backgrounder also notes interestingly, that forthcoming legislation will be in accordance with the Charter of Rights and Freedoms. The inclusion of this reference suggests that issues of privacy and non-discriminatory access will need to be addressed by any policy governing access to satellite imagery obtained by Canadian space platforms.

The recently tabled legislation, to become known as the *Remote Sensing Space Systems Act* (Government of Canada, 2004), will designate the Minister of Foreign Affairs with licensing authority over remote sensing satellite operators. According to Minister Pettigrew, “[the] Act will regulate the operation of Canadian remote sensing satellites and ensure these instruments and the information they produce are not used against the interests of Canadians... [serving] to protect the safety of Canadians and our allies.”¹⁹⁰ The Act will enable the Government of Canada to order priority access or the interruption of normal service for licensed satellites if continued operation is

¹⁸⁸ DFAIT (1999) no pagination

¹⁸⁹ Ibid.

¹⁹⁰ Government of Canada news release 136 (Nov. 23, 2004) “Canada Tables Legislation Regulating Remote Sensing Space Systems” <http://webapps.dfa-it-maeci.gc.ca/MinPub> [accessed Nov. 23, 2004]

deemed to be “injurious to Canada’s conduct of international relations or inconsistent with Canada’s international obligations.” Further, if the operation of a Canadian remote sensing satellite is deemed “injurious to the defence of Canada or the safety of Canadian Forces” then satellite operation can be restricted or interrupted.¹⁹¹

In summarizing the principles guiding the Act’s formulation, background documents note that the Government of Canada will have the right to review and approve all commercial remote sensing satellite systems including the level of foreign ownership. While regulations defining the “reasonable grounds” required by the Government of Canada to invoke shutter control have yet to be developed, operational restrictions are described as the placement of spatial, temporal and performance limitations or denials to specific customers on a case-by-case basis.

The *Remote Sensing Space Systems Act* does outline certain responsibilities that will be placed on remote sensing satellite operators, (both government and privately-owned) for registering, recording and operating satellites and their uses. Noteworthy is the requirement for operators to execute satellite control solely from Canadian territorial jurisdiction, providing command uplink and data downlink formats that enable the Government of Canada “to exercise sovereignty over the satellite” and deny unauthorized access at all times, referring to government-approved data encryption techniques. While this does not ultimately restrict control of the satellite to be administered from within Canadian territory, any operator would presumably have to be accountable to Canadian law either through citizenship, corporate registration or treaty agreement.

In addition, satellite operators will have to co-ordinate international marketing efforts with the departments of Foreign Affairs and International Trade such that commercial agreements and

¹⁹¹ Government of Canada (2004), p.10

licensing requirements are reviewed against national security and foreign affairs interests, including the possible need for pre-arranged bilateral agreements to be put in place between Canada and foreign partners similar to the commercial sovereignty arrangement that will see distribution rights for RADARSAT-2 imagery of US territory to be held by US firms. Mutual imagery restriction agreements may also be envisaged by the Canadian policy, similar to an agreement maintained between the US and Israel that disallows the highest resolution satellite imagery of either country to be commercialized.

Among the considerations to be used in licensing remote sensing space systems in Canada, “national security” is placed as the highest tasking priority next to the maintenance of satellite health and safety. The ministries noted as having authority to control access to satellite imagery or be afforded priority access include the Department of Foreign Affairs, DND and through Public Safety and Emergency Preparedness Canada, the Royal Canadian Mounted Police and the Canadian Security Intelligence Service. Of potential significance, the government departments that routinely rely on large quantities of satellite remote sensing data (Environment Canada and Natural Resources Canada) and the department responsible for the Canadian Space Agency (Industry Canada) are not mentioned in the access control provisions.

As noted, the Act provides the necessary power for the Government of Canada to order priority access to data from remote sensing satellites, and authorize the communication of this data to any person, government, agency or group. Similarly, “the Minister may restrict the provision of remote sensing products...on any conditions that the Minister considers appropriate.” Public disclosure of the substance of priority access or service interruption orders could be similarly restricted under the Act. While regulations will more explicitly guide the use of these wide-

reaching powers, it is clear that several legally-enforceable measures could be used to deny public dissemination of information, establish exclusive-use or ‘no imaging zone’ agreements with other governments or agencies, and allow operators of remote sensing satellites to operate under a veil of opacity as ordered by the Government.

A related issue addressed by the *Remote Sensing Space Systems Act* is ‘Open Skies’ – the international legal principle that permits foreign governments to request data acquired over its jurisdiction, consistent with the UN agreement *Principles Relating to Remote Sensing of the Earth from Space*. Section 8(4) of the Act describes as one of the licence conditions for remote sensing satellite operators, that “raw data and remote sensing products... about the territory of any country ... [must] be made available to the government of that country within a reasonable time, on reasonable terms and for so long as the data or products have not been disposed of...” While this provision conforms to international norms, there are various other conditions in the Act that would make it difficult for foreign countries to access data obtained over its territory including the basic problem of not knowing about imagery unless it specifically asks. If imagery is “disposed of” it is presumably unavailable, preventing knowledge of its existence. While satellite operators will be required to maintain a registry of satellite tasking information under forthcoming regulations, it is unclear whether operator licenses or registries will be publicly available.

Official news releases and policy backgrounders suggests that the proposed legislation will balance Canadian national security and foreign affairs interests with promotion of the Canadian remote sensing industry. While references to the ‘Open Skies’ principle and Canada’s international commitments indicate that the *Remote Sensing Space Systems Act* will conform to over-riding international norms and treaties regarding outer space activities, the text of the Act

indicates that territorial sovereignty concerns override economic or any other considerations. No indication of what kinds of products or applications satellite operators might be limited to or be restricted from pursuing are hinted at although ensuing regulations may yet address these issues. Protection of the environment, and public health and safety are considered only in the context of government licensing of remote sensing systems and system disposal plans, presumably to guard against terrestrial crashes of satellites. Beyond this, no notion is given that resource governance, environmental monitoring or human security issues are driving factors for the remote sensing legislation.

From a careful reading of Canada's first legislation governing remote sensing systems and accompanying background information, the EO industry is framed as having important strategic and economic significance for Canada with the potential ability to undermine crucial territorial security interests if left unregulated. The historical preoccupation of the Canadian remote sensing industry with environmental monitoring and Earth sciences is not afforded any immediate priority in the *Remote Sensing Space Systems Act*.

5.4.2 Canadian Space Policy Framework and Related Policies

Despite the embryonic nature of Canadian legislation exclusively governing remote sensing activities in Canada, the CSA has in place the *Canadian Space Policy Framework* of 1994 which guides the implementation of the Canadian civilian space program. The 1994 document provides overarching guidance for the activities of a Canadian space industry, identifying space as an area “of strategic importance to Canada's transition to a knowledge-based economy, and to the social, scientific, sovereignty, security and foreign policy objectives of the federal government.”

The policy objectives for Canada's civilian space program were assigned to and remain focussed on the following four categories, for which EO is now recognized as the most important sector for the civilian space program: space science; satellite communication and navigation systems; EO using radar remote sensing; and space robotics and automation. As expressed by Godefroy (1998), Canada's space policy has always centred on needs directly related either to Canada's geography and/or political alignment, and has evolved in a fragmented manner in contrast to US policies. While consistently resisting expenditures and policy shifts that would see Canada develop autonomous military capacities in space, sovereignty and military applications of EO have grown in tandem with the rising importance of space technologies for modern military operations.

To achieve its economically-focussed policy objectives, the Canadian government has urged a niche strategy based on a high degree of specialization. As stated in the *Space Policy Framework*, "Canada has not only made specific strategic choices about what it will do in space, it has also made choices about what it will not do."¹⁹² Clearly Canada's strategy involves no investment in launch capacity or domestic satellite navigation systems, but does rely heavily on domestic partnerships with the private sector and partnerships with other countries. As detailed in the preamble to the *Framework* provided on the CSA's website, a nation that invests US \$250 million annually in public sector space activities cannot expect to compete directly with the US that spends more than US \$28 billion annually.¹⁹³ The niche strategy has therefore been applied through a commercialization objective, which as articulated by the *Framework* is "to foster an internationally competitive, export-oriented Canadian space equipment and services sector."¹⁹⁴ To this end, the CSA has continually out-sourced upwards of 75% of its funding to industry, universities and

¹⁹² CSA (1994) "Canada's Space Policy Framework" www.space.gc.ca/asc/eng/science_industry/policy.asp#1 [March 3, 2004]

¹⁹³ Ibid. (no pagination)

¹⁹⁴ Ibid.

specialized research institutes, placing the locus of space capability in the private sector, and leaving the government to provide regulation, intellectual property management and technology transfer oversight.¹⁹⁵ The aim of the *Framework* is to achieve a long-term balance between public and private sector roles in space, commensurate with the level of commercial maturity in a given sector. For telecommunications where the commercial industry is well established, the government's role is primarily a regulatory one. For EO which has achieved semi-commercialization, the government is still a prime investor and partner with the private sector.

The 1994 *Space Policy Framework* emerged at the same time as Canada was asserting its sovereignty in other ways. Historically, the US through NORAD had assisted Canada with the task of maintaining early warning and defence systems, a task relying heavily on US military monitoring capabilities. Only in 1984 did Canada manage to negotiate back command-and-control over its airspace through a bi-national co-management arrangement for NORAD which saw the staffing of Canadian personnel at ground monitoring facilities that had been monitoring both US and Canadian airspace since the inception of NORAD.¹⁹⁶ Canada's 1994 *Defence White Paper* reinforced the Canadian position on national sovereignty and mentioned space as an important factor in the future security environment, while remaining vague on Canada's future military needs for space.¹⁹⁷ The *Space Policy Framework* became a significant aspect of Canada's assertion of sovereignty in space, particularly following the deployment of RADARSAT-1 which provided Canada with its own capacity for terrestrial and marine surveillance.

¹⁹⁵ CSA (1994) "Canada's Space Policy Framework" www.space.gc.ca/asc/eng/science_industry/policy.asp#1 [March 3, 2004]

¹⁹⁶ History of Canadian Forces Detachment Elmendorf – see www.elmendorf.af.mil/ALCOM/AKNORAD/CF-Det/index.htm [accessed October 12, 2004]

¹⁹⁷ Department of National Defence Canada (1994), p.15

The Canadian military has generally had to grapple with a growing need for rapid information provided by space technologies, without possessing autonomous capacities in space. As such, Canadian military space policy has amounted to the establishment of highly developed ground stations for receiving satellite data from international partners and allies. The *Canadian Space Policy Framework* also highlights international and domestic cooperation as a primary strategy. As stated in the *Framework*, Canada's space partnerships: "symbolize the spirit of cooperation on which the peaceful use of space depends" additionally creating "synergies between Canadian and international industrial partners" and providing leverage to expenditures "by giving Canadian researchers access to programs and technologies from which they would otherwise be excluded."¹⁹⁸

As far as military uses of space, Canada uses all of its space assets as a single strategic resource which, when necessary, may provide support to military organizations.¹⁹⁹ For example, Canada's RADARSAT remote sensing satellite has provided crucial space support for military organizations, both in Canada and elsewhere. But a gap between civilian and defence space policies exists that has been characterized by many in the defence sector as an operational challenge stifling both international cooperation and the development of military space technology in Canada. Delays in the development of the follow-on system to RADARSAT²⁰⁰ may have been experienced due to disagreements between planned civilian and military uses for the satellite, but the policy gap has also been the result of a conscious decision by successive Canadian governments not to pursue autonomous military capabilities in space.

¹⁹⁸ CSA (2004) "Industrial Policy and Development" www.space.gc.ca/asc/eng/science_industry/policy.asp [March 3, 2004]

¹⁹⁹ Godefroy (2000) p.57

²⁰⁰ Although still fully operational, the RADARSAT-1 mission was planned for five years while the operational life-span was predicted to last seven years. RADARSAT reached the end of its operational life-span in 2002.

While Canada's civilian space policy is becoming well defined, many questions remain regarding Canada's military space policy. The growing interdependence between modern military effectiveness and access to space technology raises many challenges for defence agencies not possessing a robust capacity or access. The increased use of precision-guided munitions, the need for accurate intelligence, mapping, navigation and secure communications for smaller missions requiring faster response times places numerous pressures on today's military organizations. In turn, for countries like Canada which pursues a predominantly private-sector space industry, pressures are transferred to commercial industries that must interact with governments in developing policies and technologies that address perceived market needs.

The historically civilian and private-sector driven space industry in Canada has provided ample opportunity for the development of a robust EO sector external to a military-oriented aerospace industry. As a result, Canadian space and remote sensing activities have primarily emphasized environment and resource governance issues even when expressed as sovereignty concerns. But rapidly evolving dependence upon space technologies by the US military, a desire to maintain interoperability between Canadian and US defences and competing discourses on what constitutes national security all amount to increasing pressure on the private sector to tailor its activities to the needs of military and intelligence agencies that maintain a traditional territorial comprehension of security. The *Remote Sensing Space Systems Act* is an indication that security and sovereignty concerns are the focus of Canadian EO policy development as it pertains to commercial systems.

Despite the growing incentive within the Canadian private sector to appeal to the large budgets of a liberalized US military-industrial complex, regulations and norms may yet emerge to govern commercial EO activities that prioritize the public good aspects. Forthcoming legislation as seen

in the *Remote Sensing Space Systems Act* suggests that economic growth and political acceptance by dominant trading partners are major priorities for Canada moving forward but international commitments and norms suggest that peaceful common-good purposes will be sought from private-sector EO businesses as well as from government. While the existence and direction of US policies governing EO cannot be ignored by Canada due to the dominant trade relationship between the two countries, US policies have, by contrast with Canadian policies, had a longer history of addressing commercial and territorial sovereignty concerns.

5.4.3 US Commercial Remote Sensing Policy

Policies governing commercial satellite operation in the US are well developed because space-based remote sensing has been so heavily dominated by the US historically. While Landsat, the world's first civilian remote sensing satellite was launched in 1972, the US government began, in 1979, to officially "seek ways to further private sector opportunities in civil land remote sensing activities... with the goal of eventual operation of these activities by the private sector."²⁰¹

The *Land Remote-Sensing Commercialization Act* of 1984 was the first major effort aimed at encouraging US private-sector involvement in satellite remote sensing, placing the Department of Commerce (DoC) in charge of licensing, archiving and oversight for anticipated new entrants into the remote sensing business. The 1984 policy provided for private firms to commercially distribute data and imagery from the US government's Landsat program in an understanding that offloading government involvement to the private sector for the information-segment of Landsat would reduce management costs of the program substantially, and be the best way for the US to compete commercially in a looming international remote sensing data market. Through the 1984

²⁰¹ Announcement of the President's Decision Directive-54 Concerning Land Remote Sensing Activities, The White House, Washington, DC, Nov. 20, 1979.

policy, the US government stated that “the continuous civilian collection and utilization of land remote-sensing data from space are of major benefit in managing the Earth's natural resources and in planning and conducting many other activities of economic importance.” As such, maintaining pre-eminence in civil remote sensing was considered to be in the primary national interest.

Efforts were broadly aimed at promoting the beneficial uses of remote-sensing consistent with prevailing international norms. The 1984 policy recognized the ‘common good’ aspects of certain types of EO by prohibiting the privatization and commercialization of weather data obtained by US meteorological satellites and instructed Landsat data marketing to be conducted on a non-discriminatory basis. Despite substantial government subsidies to EOSAT – the company selected to market Landsat data for a ten year period – it was hoped that competitive, free-market-driven private-sector involvement would solidify US worldwide leadership in civil remote sensing. The 1984 policy limited private sector activities to the information-segment however and provided a high degree of control to the US government commensurate with its historical perception that space-based remote sensing was of strategic interest to national security. The early policy proved too restrictive and amounted to forced commercialization which dramatically increased imagery prices and a lack of planning for follow-on satellite systems. The two-fold increase in Landsat data prices from 1982 to 1985 caused many former customers to turn to other sources including SPOT, for which imagery sales were surpassing those of EOSAT by 1989.²⁰²

In 1992, the *Land Remote Sensing Policy Act* repealed the 1984 law, returning authority for managing the civilian Landsat program back to NASA and DoD in recognition that early privatization attempts had failed. The 1992 Act also provided for the licensing of private sector parties to operate remote sensing space systems in addition to the information-segment. The new

²⁰² Dehqanzada et al. (2000), pp.42-43

policy also recognized ‘public good’ aspects of remote sensing by directing Landsat data to be provided to governments, educational institutions and other non-profit users at reasonable cost.

In a subsequent policy decision, brought on by recognition that higher resolution satellite imagery than that offered by Landsat was being sought globally, the US government rendered a decision to encourage the private sector to capture the market in high-resolution imagery collection. The US *Policy on Foreign Access to Remote Sensing Space Capabilities* was issued in 1994, allowing imagery from optical sensors to be commercialized and distributed by the private sector at higher spatial resolutions. This policy also established ‘shutter control’ guidelines by which the government could control the sale of selected images “when national security or international obligations and/or foreign policies may be compromised.”²⁰³ It was hoped that increased US exports of imagery, satellite systems and ground stations would subsequently render the wider global market for geospatial information subject to regulations stipulated by US policies.

In 2000, NOAA issued regulations implementing Title II of the 1992 *Land Remote-sensing Policy Act*, which laid the groundwork for the commercialization of certain government remote-sensing satellite imagery products (primarily from Landsat). In addition, the new regulations codified the licensing process and defined the terms for which shutter control could be applied. An update to existing US policies came again in 2003 with the *Commercial Remote Sensing Policy*, which provides further guidance to private operators of EO satellites and commercial suppliers of geospatial data and imagery. The goal stated for this policy is “to advance and protect US national security and foreign policy interests by maintaining the nation’s leadership in remote sensing space activities, and by sustaining and enhancing the US remote sensing industry.” This goal is to be achieved by establishing maximal US government reliance

²⁰³ *Land Remote Sensing Policy Act* (1992) <http://geo.arc.nasa.gov/sgc/landsat/15USCch82.html> [Nov. 17, 04]

on US commercial remote sensing space capabilities to meet intelligence and military needs. The policy states that doing so “will also foster economic growth, contribute to environmental stewardship, and enable scientific and technological excellence.”

The *Commercial Remote Sensing Policy* (White House, 2003) supersedes the 1994 policy and further requires private satellite operators to account for all images acquired, allowing government access to the list of images. Government-approved encryption devices must be used along with downlink data formats that can be accessed and used by the US government. Government approval must also be sought by private satellite operators prior to entering into “significant or substantial” accords with new foreign imagery customers. Through the establishment of mutual dependencies between intelligence and military agencies and the private EO industry, it is envisaged that the new policy will balance the ‘common good’ needs for environmental monitoring and scientific applications of EO with US sovereignty and defence needs:

A robust US commercial remote sensing space industry can augment and potentially replace some United States Government capabilities and can contribute to US military, intelligence, foreign policy, homeland security, and civil objectives, as well as US economic competitiveness.²⁰⁴

While one of the goals stated in the US policy includes contributing to “environmental stewardship,” economic competitiveness and maintenance of national advantage are clear priorities. Detailed analyses of US remote sensing policies and risks facing the commercial EO industry have been conducted by the RAND Corporation (O’Connell et al, 2001; Baker et al, 2004) which have cited “public access to low-cost or free overhead US government imagery” as a primary risk that could “reduce the potential demand for more expensive commercial satellite imagery.”²⁰⁵ RAND studies and the 2003 policy adjustment suggest that the viability and

²⁰⁴ White House (2003)

²⁰⁵ O’Connell et al. (2001), p.xvi

commercial trajectory of private-sector EO firms might be increasingly influenced by both the availability of imagery from civilian or foreign providers, and the subsidies provided by national military and intelligence agencies. The US policy encourages companies to “build and operate commercial remote sensing space systems whose operational capabilities, products, and services are superior to any current or planned foreign commercial systems.”²⁰⁶ It further explains that Defense, Intelligence and civil agencies requiring satellite imagery shall “outsource functions to enable the [US] Government to rely to the maximum practical extent on commercial remote sensing space capabilities for filling imagery and geospatial needs.”²⁰⁷

In addition to establishing strong co-dependencies between the US Government and its EO industry, shutter control will continue to be a government prerogative which can range from licence conditions being placed on satellite operators to the restriction of operation of commercial EO systems in order to limit collection and/or dissemination of certain data and products. While the provisions contained in US law for shutter control have generally been limited to a unique agreement in place between the US and Israel,²⁰⁸ US agencies have entered into exclusive contracts with private EO firms that amount to ‘dollar shutter control’.²⁰⁹

Concerning foreign-access to US commercial remote sensing products, the *Commercial Remote Sensing Policy* explains that: “It is in US national security, foreign policy, and economic interests that US industry compete successfully as providers of remote sensing space products and capabilities to foreign governments and foreign commercial users.” As

²⁰⁶ White House (2003), p.4

²⁰⁷ Ibid., p.4

²⁰⁸ In 1996, US Congress passed the Kyl-Bingaman amendment as part of the 1997 Defence Authorization Act that limits satellite imaging of Israel to resolutions equal or greater than readily commercially available.

²⁰⁹ Katherine McIntire Peters (April 1, 1998) “Military Depends on Civilian Satellites” *GovExec.com*; “Pentagon turns to commercial satellites to ease wartime data squeeze” *Globeandmail.com* (March 28, 2003); “Civilian Satellites Used to Help Plan Attacks in Afghanistan” *SpaceDaily.com* (May 17, 2003)

the historical leader in providing global environmental monitoring information from space, the contextualization of this provision of data as a national security and economic prerogative suggests that common good applications of EO from the commercial sector are less of a priority than securing the national interests.

For EO systems operated by US firms, national policies have required conformance to international norms by stating that foreign countries must be given “reasonable terms and conditions” for obtaining imagery taken of its territory under the ‘Open Skies’ principle.²¹⁰ Repeatedly, US remote sensing policy decisions highlight certain ‘common good’ aspects of EO while pronouncing that “vital national security, foreign policy, economic, and civil interests depend on the United States ability to remotely sense Earth from space.”²¹¹ US remote sensing policies have traditionally emphasized ‘common good’ aspects and a need for non-discriminatory data access based on international norms while also framing foreign EO capabilities as a potential threat to US sovereignty.

The duality of purpose in US remote sensing policies, serving as both a protective umbrella for US interests and allowing for limited transfer of authority and control to private actors, resulted in a slow evolution of private-sector EO services while lesser regulated industries elsewhere grew substantially. Despite efforts by successive administrations to encourage US geospatial industry pre-eminence, non-US technology has kept pace, feeding perceptions that EO is a strategic industry where data and technology must be pursued and controlled to protect national interests.

²¹⁰ Section 202b, clause 2 of the 1992 Land Remote Sensing Policy Act (Public Law 102-555) and Principle XII of the 1987 UN General Assembly Resolution of Principles Relating to Remote Sensing of the Earth from Space

²¹¹ The White House (2003)

5.4.4 US Space Policy

The overall space industry in the US is guided by the 1996 *National Space Policy* (US National Science and Technology Council, 1996). This document sets the goals of the US space program as enhancing knowledge of the Earth, the solar system and the universe, strengthening and maintaining the national security of the US, enhancing the economic competitiveness, scientific and technical capabilities of the US and encouraging state, local and private sector investment in, and use of, space technologies. The US *National Space Policy* also seeks to promote international cooperation to further its domestic, national security, and foreign policy objectives.

Explicitly referring to prevailing international space law which mandates the peaceful uses of outer space, the *National Space Policy* defines peaceful purposes as allowing “defense and intelligence-related activities in pursuit of national security and other goals.” The policy also states the US rejection “of any claim to sovereignty by any nation over outer space or celestial bodies, or any portion thereof, and rejects any limitations on the fundamental right of sovereign nations to acquire data from space.”

The *National Space Policy* provides for separate civilian and national security space programs where different needs dictate, and presents guidelines for the implementation of both programs. Among other civilian activities, NASA is tasked with undertaking “a program of long-term observation, research, and analysis of the Earth's land, oceans, atmosphere and their interactions, including continual measurements” whereas the national security space program overseen by the Secretary of Defence and the Director of Central Intelligence is to “support military operations worldwide, monitor and respond to strategic military threats, and monitor arms control and non-proliferation agreements.”

The civilian space agency is tasked with using “relevant private sector remote sensing capabilities, data, and information products and establish[ing] a demonstration program to purchase data products from the US private sector.” Of note, the DoC, through NOAA, has the lead responsibility for managing Earth observations necessary to meet civil requirements. In this role, the DoC is to “acquire data, conduct research and analyses, and make required predictions about the Earth's environment.” Additionally, the DoC will “consolidate operational US Government civil requirements for data products, and define and operate Earth observation systems in support of operational monitoring needs.” The importance of the EO industry to the national economy of the US is clearly seen when the Department of the Interior, through the US Geological Survey (USGS), is only tasked by policy with “maintain[ing] the national archive of land remote sensing data and other surface data” but not with establishing mission priorities for civil EO platforms. As the department additionally responsible for licensing private EO satellite operators, DoC/NOAA is in the important position of influencing the future trajectory of the commercial EO industry.

The *National Space Policy*'s guidelines for the national security space program state that “DoD shall maintain the capability to execute the mission areas of space support, force enhancement, space control, and force application.” Activities include “providing support for the United States' inherent right of self-defense,” deterring, warning, and “defending against enemy attack, assuring that hostile forces cannot prevent [US] use of space, countering, if necessary, space systems and services used for hostile purposes, enhancing operations of US and allied forces, ensuring [US] ability to conduct military and intelligence space-related activities,” and supporting the activities of national policy makers. As a final note, the document asserts that “the United States will develop, operate and maintain space control capabilities to ensure freedom of action in space and, if directed, deny such freedom of action to adversaries.”

For guidance provided to the intelligence space sector, the *National Space Policy* states that satellite photoreconnaissance capabilities are to be maintained to include “a near real-time capability ... used to provide defense-related information for indications and warning, and the planning and conduct of military operations” for which “[t]he nature, the attributable collected information and the operational details of intelligence space activities will be classified.” A singular reference is also provided to the dual-use nature of the intelligence-sector space capabilities, in that “satellite photoreconnaissance can be used to collect scientific and environmental data and data on natural or man-made disasters, and such data can be disseminated to authorized federal agencies.”

Guidance is also provided to the commercial space sector, which reveals that the 2003 *Commercial Remote Sensing Policy* directly extends from the *National Space Policy*:

The fundamental goal of US commercial space policy is to support and enhance US economic competitiveness in space activities while protecting US national security and foreign policy interests. Expanding US commercial space activities will generate economic benefits for the Nation and provide the US Government with an increasing range of space goods and services.²¹²

The US government is mandated to “purchase commercially available space goods and services to the fullest extent possible” to stimulate private sector investment. Further, “the US Government will facilitate stable and predictable US commercial sector access to appropriate US Government space-related hardware, facilities and data.” Government space sectors are also tasked with eliminating “laws and regulations that unnecessarily impede commercial space sector activities.” Despite this however, the US government still reserves itself the right to use US commercial hardware, facilities and data “on a priority basis to meet national security and critical civil sector

²¹² The White House (2003)

requirements” as enunciated in both the *National Space Policy* and the *Commercial Remote Sensing Policy*.

An overall government role in space-based EO is also defined in the *National Space Policy* based on its ability to provide “information useful for protecting public health, safety, and national security.” To this end, the US Government commits itself in the policy to continuing to “develop and operate space-based Earth observing systems, including satellites, instruments, data management and dissemination activities,” including research and development, support for commercial ventures and for the collection of environmental data.

While the value of EO technologies to global governance issues is noted through reference to satellite-based verification of arms control treaties, there is some brief mention of international cooperation in the context of benefits being provided to US interests. These undertakings include defining an integrated global observing strategy for civil applications, coordinating US civil EO systems in coordination with other national and international systems for efficient collection and dissemination of environmental measurements, and the obtaining of EO data from non-US sources. Lastly, support is indicated in the *National Space Policy* for providing public, non-discriminatory direct read-out of data from US civil space systems, as appropriate to US interests.

US Government space sectors are mandated by the *National Space Policy* to coordinate and consolidate EO activities to reduce overlaps in development, measurements, information processing, and archiving, where cost-effective and practical. To this end, the National Polar-Orbiting Environmental Satellite System (NPOESS) is identified as one such converged system that is tasked with satisfying both civil and national security requirements. Representative of the trend that sees increasingly merged systems for both civil and defence EO sectors is the statement

that “NASA, DoC/NOAA, DoD, the Intelligence Community, and DoE shall work together to identify, develop, demonstrate, and transition advanced technologies to US Earth observation satellite systems.” In addition, “the US Government space sectors shall continue to identify national security products and services that can contribute to global change research and civil environmental monitoring,” revealing an intended two-way direction for civil satellites to inform on national security matters, but for classified data from national security programs also to be provided to civil groups when possible or necessary.

Apart from the well defined policies in the US that support a private-sector remote sensing and EO industry, various other policy-related influences exist in the US that range from the civilian and private sectors to the future plans of the US military. From *Vision for 2020* (US Space Command, 1997), a somewhat alarming future outlook for military space policy is articulated, expanding on the concept of “space control” referred to in the *National Space Policy*. Claiming that the emergence of space power follows the historical model established by land, sea and air-based militaries in protecting national interests and investments, outer space is seen as the fourth medium of warfare by the US Space Command. *Vision for 2020* urges the preservation of “permanent pre-eminence” and “full spectrum dominance” for US interests in space. While it is clear that space technologies have supported land, sea and air military operations over the past several decades, the US Space Command clearly sees space power evolving into a separate and equal medium of warfare where “space forces will emerge to protect military and commercial national interests and investment in the space medium due to their increasing importance.”²¹³

From US military planning documents, control and dominance over the wide perspective offered by outer space appears to be the single most important geo-strategy, an issue that will increasingly

²¹³ US Space Command (1997), p.7

affect commercial industries that are involved in space-based technology. *Vision for 2020*

summarizes that:

As commercial space systems provide global information and nations tap into this source for military purposes, protecting (as well as negating) these nonmilitary space systems will become more difficult. Due to the importance of commerce and its effects on national security, the US may evolve into the guardian of space commerce—similar to the historical example of navies protecting sea commerce.²¹⁴

Any cursory examination of official national security and military documents in the US reveals a continued reliance on the deterrence mindset of the Cold War era, where military might and technological superiority are the imperatives. The main difference between Cold War ideologies and modern military priorities however, is the level to which information, rapid access to it, and control of it, has become important. Central to this flow of information required by modern military strategists is the monitoring capability offered by EO satellites. According to the US Space Command, “operational superiority” for military actors will increasingly require “information superiority,” an important trend that will clearly influence the commercial EO industry in the future.²¹⁵

²¹⁴ US Space Command (1997), p.10

²¹⁵ *Ibid.*, p.5

5.5 Summary of Commercial EO Markets and Industry Trends

Readily visible from the history of satellite remote sensing development in Canada and the US is that Canadian efforts were primarily civilian, involving the participation of research institutions, private-sector companies and government departments with a centralized focus that supported Canada's resource-based economy. In the US, several parallel government-controlled remote sensing industries underwent development, with the activities of the defence and intelligence sectors necessitating strict control over technology transfer and knowledge sharing with the public and private sectors. Essentially, Canada has to date, pursued remote sensing technology as a single strategic resource while the US industry has traditionally seen bifurcation between the strategic needs of the military and the civilian public-good aspects of EO.

International treaties and norms governing the use of airspace and outer space have similarly influenced civilian EO development in Canada and the US while military agencies have maintained a separate and independent agenda for the use of remote sensing. Canada's international outlook and cooperative frameworks have enabled its EO industry to maintain and benefit from links to a multidisciplinary scientific field that is global in scope, while the mere size of the US space industry has provided its EO industry with a similar global reach.

A primary difference between large and small scale EO programs is the allocation of financial resources to the sector commensurate with risk tolerance which may have a cultural dimension based on perceived security imperatives. While public sector funding of the space industry in Canada has averaged about \$250 million over the past few years, the US spends an average of about \$28 billion annually.²¹⁶ Based on per-capita funding of space-industry activities, the figures

²¹⁶ CSA (2004) "Industrial Policy and Development" www.space.gc.ca/asc/eng/science_industry/policy.asp [accessed Nov 3, 2004] – all dollar figures in US funds

become even more striking. In Canada, an average of \$8 of public funds is spent per person on space sector activities compared to \$90 per person in the US, representing over 10 times the per-capita investment made in Canada.²¹⁷ As an additional indication of the scale of US investments in space development, 95% of the global investment in military space technology and 64% of the global investment in civilian space activity is based in the US.²¹⁸

As a proportion of global EO imagery and data revenues, the US DoC has reported that between 1996 and 2002 the private-sector EO industry in the US accounted for an average of 30% of the global satellite imagery revenues. Imagery sales attributed to France's SPOT platform equalled the US total at an average of 30% during the same period. Canada's RADARSAT has reportedly garnered 15% of the world market over the past several years with the remaining 25% of the global EO market attributed to sales by the combined ventures of ESA, Russia, India and Japan.²¹⁹ Overall, despite the varied nature of domestic efforts and investments made to develop space industries in Canada and the US, these figures indicate that Canada's niche strategy of developing expertise in the EO sector while not pursuing capabilities in other areas has allowed it to keep pace with other countries.

According to a report produced for the US DoC, sales of pre-value added satellite imagery in the US have grown 20% from 1996 to 2002.²²⁰ In comparison, total Canadian EO revenues grew by an average of 40% in the five year period leading up to 2002.²²¹ A 2002 study undertaken by a consortium of US industry associations and civilian space agencies predicted that US revenues

²¹⁷ based on \$250 M/32 million people in Canada vs. \$28 B/300 million people in the US in 2000-2002

²¹⁸ Alain Dupas (2002) "Civilian Uses of Space," a presentation to the Conference on Outer Space and Global Security, 26-27 Nov. 26-27 2002, Geneva

²¹⁹ Futron (2001), pp.4-5

²²⁰ Ibid., p.54

²²¹ CSA (2004), p.13

from commercial sales of EO products and services would continue to grow by 10 to 13% annually between 2001 and 2012.²²² Another estimate predicted that world-wide sales of commercial satellite imagery would grow at a rate of 24% compounded over the 2000-2007 timeframe.²²³ Projections of the size of the global satellite imagery market based on the year 2000 have ranged widely from \$2 billion per year to an astonishing \$20 billion (all figures in US dollars) while the actual demand for satellite remote sensing has been limited by its high cost and alternative, lower-cost aerial remote sensing imagery.

Reasons for over-predicting commercial EO markets may stem from unfulfilled expectations that Cold War dividends and changing national security priorities would remove barriers to commercial space development. Pricing and access policies governing EO have been blamed for slow growth of a commercial industry but the technology-driven satellite market has also been slow to evolve into an information and needs-driven market that provides easily-accessible applications for a variety of non-technical users. According to the CSA, a gap exists between EO data providers and users: “Hindering the development of a commercial market are two key factors: the lack of understanding on the part of potential users as to the benefits of EO data products, and most importantly, the existence of a gap between the data providers and the user communities.”²²⁴

The economic importance of geospatial information for businesses remains a growth opportunity for satellite imagery. O’Connell et al. (2001) have estimated that 75% of business data have some type of geospatial content, but that less than 10% of businesses use such data in a traditional geographic context. GIS, increased computing power and the Internet are all enabling the rapid

²²² ASPRS (2004), p.46

²²³ CSA (2003a), p.49

²²⁴ Ibid., p.35

integration of geospatial data with other decision-making information to create many powerful applications for businesses. Examples of readily available sources of on-line remote sensing data include the GlobeXplorer and Carterra applications described above as well as the Alexandria Digital Library, US National Geo-spatial Data Clearinghouse, Microsoft's Terraserver, the MIT server of DOQQ's and Natural Resources Canada's GeoConnections Discovery Portal, Geospatial Data Infrastructure and GeoGratis programs.²²⁵

There is little question that businesses are seeking more use of geospatial information to improve productivity and efficiency, but the question remains as to how much of a need exists for highly specialized satellite imagery to augment other sources of data for business decision-making. EO imagery is still only a small part of a broader geospatial marketplace where location, technical and social knowledge of environments is only enhanced cognitively by the visual aspects of imagery. According to O'Connell et al. (2001), "a geospatial information user has many decisions to make about what types of data to use from which sources...many users, such as traditional GIS users ... would rather use traditional GIS point, line, and polygon data than deal with image datasets."²²⁶ In this respect while large resource development enterprises have benefited from the use of remote sensing imagery and data, many discrete commercial applications may not need satellite imagery.

The CSA's *Global Space Sector Market Trends and Drivers – Year 2002 Edition* (CSA, 2003a) provides insight into the processes of EO commercialization and private-sector expansion into the area of satellite remote sensing. According to the CSA, the global satellite remote sensing industry is "semi-commercialized" meaning that government intervention is still high, with early growth supported by a heavy proportion of public funding. In this early commercial phase,

²²⁵ see: www.alexandria.ucsb.edu; www.fgdc.gov; www.terraserver.com; www.mapquest.com; ortho.mit.edu; ceonet.ccrs.nrcan.gc.ca

²²⁶ O'Connell et al. (2001), p. 39

“growth is propelled by a growing recognition of the major business and public good benefits from using EO information.”²²⁷

In the first few years following deployment of RADARSAT-1, CSA reported that “the biggest beneficiary [of the RADARSAT program] is the planet itself,”²²⁸ contrasting with more recent reports that prioritize the economic benefits of EO commercialization and public-private partnerships. These economic benefits relate to the generation of employment for Canadians in the geospatial sector, increased export sales for technology and data relating to remote sensing, and the growth of small and medium-sized enterprises involved in value-added product development. Thus, the recognition of major public good benefits arising from commercial EO is largely contextualized in terms of economic security outcomes.

An overall transition can be seen through CSA documentation of the RADARSAT program over its lifespan from an emphasis placed on research and development to an identification of the priorities of the commercial sector. Most recent reports claim that commercialization has spawned increasing remote sensing expertise in Canada and abroad, contrasting with earlier reports that equate knowledge, research and development programs with knowledge of Earth systems science and the environment. The subtle shift in tone and emphasis from planetary studies and environmental applications towards applications in the purely commercial realm suggest that private interests are less aligned with the priorities of governments and civil space agencies. Indeed, according to interviews with both government remote sensing specialists and marketing specialists in private EO firms, private sector interests are inherently different.

²²⁷ CSA (2003a), p.33

²²⁸ CSA (1999a), p.1

In 2001, despite semi-commercialization, Canada's remote sensing industry derived the significant majority of its domestic revenues from non-government (i.e. private) sources whereas civil and private sources of revenue in the US were approximately even (CSA, 2004; ASPRS, 2004). With EO representing the second largest sector of the space technology economy in Canada next to telecommunications, the interests of the private EO industry are likely to increasingly influence policy development that seeks to balance private sector commercial success with a provision of services to the public. In the US EO market which exhibits the most privatization, satellite remote sensing is far less dominant a component of the overall space industry which is composed primarily of telecommunications, space transportation and GPS markets. Even though Space Imaging, Digital Globe and OrbImage have all financed their business costs from private sources, they strongly benefit from government intervention and financing. Government agencies in the US are expected to account for over half of EO revenues through to 2006.²²⁹

Of the demonstrated markets for commercial EO, the strongest application area as described by the various private-sector and public-sector market forecasts studied, is consistently split between environmental/resource mapping and defence/intelligence surveillance markets. Environmental science applications are often cited as a promising commercial market area for private-sector EO firms in Canada as this has been the primary use of RADARSAT as managed by the civilian sector. Predicted growth in this area is small however compared to that predicted to come from resource development sectors such as oil and gas exploration and from the defence/surveillance market. In the US, the same trend appears although a traditional commercial market has already emerged in the defence/intelligence sector for private EO firms. Overall, the clients of private-sector EO firms are predicted to remain firmly within the government-sector but civilian

²²⁹ CSA (2003a), p.36

environmental monitoring programs are expected to continue, with defence/intelligence programs becoming more reliant on commercial EO providers. The continuing role of civil space agencies in providing for public good applications of EO may therefore limit private-sector interest in this application area while opportunities for growth will be found in the resource mapping and defence/intelligence market segments.

What appears to be the impact of a large government sector clientele for the private-sector EO industry is that the security and economic outcomes of sovereign states are prioritized to a greater extent than the so-called ‘common good’ applications of EO that inform on environmental conditions and assist international bodies with global governance issues. A survey of over 40 Chief Executive Officers representing close to 20% of the core geospatial companies in the US indicated a strong understanding that based on 2001 revenues, national and ‘global security’ applications would dominate the EO market in years to come. In this case, ‘security’ has a formulation most closely linked to the activity of state military and intelligence agencies concerned with territorial sovereignty. Other major applications categories included civil government use (15%) and general mapping (15%) with environment, agriculture and forestry as independent categories, each comprising less than 5% of the emerging opportunities.²³⁰ While large civil agencies such as NASA are fully expected to continue providing common good EO applications, the evidence for the private sector in the US points to very little promise of profitability in this sector.

RSI’s own projected sales for RADARSAT-2 compared to known statistics for RADARSAT-1 indicate a marked increase in defence applications for the follow-on satellite. As a percentage of the total, defence sales for RADARSAT-1 were reported as 16% compared to a predicted market

²³⁰ ASPRS (2004), pp.20-29

of 27% for RADARSAT-2. Sales of data and applications for marine surveillance were also predicted to rise from 9% to 18% for the new sensor under private-sector direction. While agricultural applications were also predicted to rise significantly from 8% to 16% by RSI's estimates, mapping and sea ice applications were predicted to drop from 24% and 17% to 11% and 14%, respectively. Quite clearly indicated within the text of RSI's commercialization plan is how the new sensor will appeal to the defence establishment, noting that defence requirements have driven the need for many of the design improvements for the new sensor including higher resolution over relatively small spatial areas, frequent re-visit times and timely delivery of data.²³¹

As RSI's commercialization plan indicates, "improvements in civilian satellite capabilities combined with relatively steady defence budgets, but increasing mandates, will likely drive a dual-use capability whereby civilian sensors fill both defence and civilian user-requirements."²³² The large predicted market for commercial remote sensing imagery for military and intelligence has likely resulted from the transition underway that has states viewing sovereignty concerns through the lens of the national economy as well as through political and territorial autonomy over valuable natural resources. The proven international applications of EO satellites for obtaining global coverage of 'restricted areas' without concerns over territorial or aerospace sovereignty has long been of use to military agencies. If this continues to be the dominant commercial sector for EO, then SAR systems such as RADARSAT may offer an even greater advantage to defence and intelligence agencies than optical sensors, because darkness, cloud cover or other obscuring atmospheric features are not large factors limiting the monitoring capability of SAR. In this respect, RADARSAT-2's commercial viability may indeed become closely linked to the military and intelligence budget cycle, particularly in the US.

²³¹ Staples et al. (2004), p.10

²³² Ibid., p.12

In summary, the markets for satellite imagery will likely grow, although the pace and scope of this growth will likely be driven by four factors: the level of government interference; imagery pricing; timeliness of data access; and the ability of satellite operators to open or expand imagery markets. One primarily underserved market appears to be waiting to be exploited by private-sector EO firms – the global environmental monitoring market.

5.6 Summary of Trends in EO Policy Development, Privatization and (de)Regulation

The expression of national sovereignty concerns within remote sensing legislation provides evidence that both Canada and the US are hesitant to allow a full flowering of global transparency to emerge through domestic EO industries. If such global transparency was to emerge through the global geospatial marketplace, the US position articulated primarily in military doctrine but also in commercial remote sensing policies is that it should maintain a hegemonic presence in this industry to control it. While the Canadian landmass and natural resource endowments are larger by comparison, US national security interests are significantly broader geographically placing a greater need for the US military to analyze and address the trajectory of space technology development. Unilateral measures to assert control in space are indeed being considered by the US military but US concern for its territorial and – to a lesser-degree – economic sovereignty has also influenced policy development in other countries, most notably with Canada's *Remote Sensing Space Systems Act* which closely resembles existing US legislation.

US legislation, while comparatively highly developed, portrays a glaring contradiction between the pursuit of economic interests and national security interests, powerful drivers of the EO industry that are working at cross-purposes. The prevailing formulation of 'security' as a national-level concern prioritizing territorial protection first, and the economy second can be seen

as largely responsible for the contradiction. US export controls had an impact when the US held a near-monopoly on advanced satellite technology, but with a burgeoning global EO market outside the US, export restrictions have propelled individual states to establish their own EO programs, in turn reducing the competitive market for US companies.

In an industry that has been so traditionally driven by technology, the long-standing purposes of EO technologies can be seen to have had a primary effect on envisaged commercial uses. In Canada where remote sensing has long been about resource management and ice monitoring, the discourse in the EO community has favoured civil security uses of a sensor operating in the non-visible spectrum for ice, oil spill and natural disaster monitoring. In the US where remote sensing technology has had primary application to the military, three major EO companies have all developed similar sensors that operate in the optical and near infra-red range in high resolution – characteristics most matching those needed by the military to assert territorial sovereignty and not overly sufficient for environmental planners concerned with long-term reliable repeat monitoring.

According to the perceptions of private remote sensing satellite operators, commercial EO is a very highly regulated industry. Government policies support the privatization of space-based remote sensing services, understanding that the private-sector is the appropriate place for these technologies to grow and become economically viable in a global marketplace. Governments at the same time claim EO products and services to be crucial to state sovereignty, economic development and natural resources governance and therefore seek to regulate the imagery and technology aspects of the private EO industry largely through controls on exports while maintaining low cost and expanded access policies for ‘common good’ data from long-standing civil programs.

As a national enterprise, governments are likely to maintain a strong involvement in the use and development of common good applications for EO, despite continued privatization. In the US, the continuous data record (since 1972) of the Landsat Program has proven to be an invaluable resource for researchers. Of all global change studies that use Landsat data, one of the characteristics of the data set of greatest value is the length of the data record. The historical record of Landsat data provides documentary evidence on change in area and extent of a process and the rate of process change. Because of these characteristics, Landsat data have become fundamentally important to modeling phenomena that affect the global environment such as the distribution of snow and ice, vegetation growth or land-use changes.

The emergence of private-sector EO satellite operators has now created a competitive market between commercial remote-sensing products and the sale of imagery from Landsat. The US Geological Survey (USGS) and its Earth Resources Observation System Data Center sells medium resolution (15 meters panchromatic and 30 meters multispectral) imagery, but also provides images at no charge on a case-by-case basis, a controversial activity as seen by many private EO firms who sell imagery ranging from \$500 per scene to over \$4000 per scene. In part to address the concerns of private EO firms and to promote their competitive position in the global economy, large defence and intelligence contracts have been awarded to private EO firms in the US for imagery and technological development, serving to embroil these firms deeper into a reformulated military-industrial complex.

US interests in the commercial success or failure of private-sector EO firms have been continually marked by large government subsidies to commercial firms throughout the history of US remote sensing development, a trend that is appearing in the Canadian context as well. Perhaps rooted in

the broader perception that national benefits will accrue from having a robust satellite industry, benefits have also been described as including technical leadership, skills and know-how in critical technologies, enhanced government access to technological innovations, and national access to a wide range of commercial applications that supplement government EO capabilities to serve defence, intelligence and foreign affairs interests.²³³

After 9/11, civilian programs within NASA began to serve several military needs, a trend which promises to continue. Wirbel (2002) reported that NASA's Sea-Wide Field Studies (Sea-WiFS) sensor onboard the OrbImage's OrbView-2 satellite played a critical role in spotting Taliban forces in Afghanistan. Ties between NASA and the intelligence community were drawn closer following the 2002 opening of a Transformational Communications Office linking NASA communication networks in space with US military agencies.²³⁴ In 2003, the NGA (the geographic intelligence information arm of the US military) awarded DigitalGlobe, OrbImage and Space Imaging with imagery contracts that could reach \$500 million over five years. The NGA's \$35 million expenditure for commercial satellite imagery in 2002 was anticipated to rise as much as 300 % over the coming year.²³⁵ In 2004, DigitalGlobe and OrbImage were awarded additional contracts worth up to another \$500 million to fund the construction of follow-on satellite systems that will be designed to directly address US defence and military imagery needs.

The growing integration of military and defence sectors with private EO firms as supported by the US remote sensing policy reaffirms a strong military involvement in the US space sector. The stated intent of US national security agencies is to design a future systems architecture which

²³³ O'Connell et al. (2001) p.xii

²³⁴ US Air Force, Press Release (Sept. 3, 2002), "Transformational Communications Office Formed" accessed at www.af.mil/mediacenter/pressrelease_print.asp?prID=123006700 [accessed Nov. 1, 04]

²³⁵ Dan Caterinicchia (May 14, 2003) "Commercial satellite policy released" available at www.fcw.com/fcw/articles/2003/0512/web-sat-05-14-03.asp [accessed Nov. 1, 04] ... all dollar figures in \$US

takes maximum advantage of commercial capabilities which over the longer term will likely have an effect on the design of these capabilities. While civilian satellites have thus far provided relatively cheap and continuous data for environmental monitoring, the higher resolution imagery available from private EO satellites has remained an expensive proposition for academic researchers and civilian groups. Policies supporting national EO industries and military dependencies on private-sector EO appear to somewhat undermine the goals of global environmental monitoring efforts and wider transparent uses of EO.

Through economic liberalization, globalization of the EO industry and trends towards privatization and commercialization of the traditionally government-led enterprise of satellite remote sensing, both Canadian and US Governments are relying more on private industries for EO needs. Indeed, as a result of technology transfer and deregulation, the private industry is now largely being tasked in both countries with the design, deployment and operational management of new civilian satellite platforms.²³⁶

While it is clear that Canada's space industry has developed in a uniquely different fashion from the US industry, without a well defined Canadian remote sensing regulatory regime, it is difficult to predict whether these differences will be maintained in the future. Based on the similarities between Canada's *Remote Sensing Space Systems Act* and existing US legislation, and based on the similar trends toward privatization of the EO industry in both countries, a closer alignment of priorities, identities and perceived market needs is likely to emerge.

²³⁶ MacDonald Dettwiler is managing most aspects of the new RADARSAT-2 project and two out of the three private US firms analysed in this dissertation have been awarded substantial government contracts to fund follow-on satellite systems designed to meet the needs of civilian, defence and intelligence government sectors.

6.0 DISCUSSION

The above analysis of the commercial EO industry, its history, governing policies and marketing approaches reveals a number of contested assumptions about the role of a private EO industry to inform on global issues. This chapter will provide a discussion of several issues associated with emergent trends in private-sector EO, particularly as they relate to different security themes.

6.1 EO and Global (Environmental) Governance

Even society as a whole, a nation, or all existing societies put together, are not owners of the Earth. They are merely its occupants, its users; and like good caretakers, they must hand it down improved to subsequent generations.
(Marx, *Capital*, Vol. 1)

Satellite EO is a technology whose societal impact transcends the space between sovereign territory and the global commons. Originally conceived to pursue the sovereign interests of states, EO is now emerging as a technology that can support a general shift in the popular understanding of sovereignty and security issues. Early photography of the Earth and the stories of astronauts distributed to the imaginations of the world through the medium of satellite communications were instrumental in forging the environmental movement of the 1970's. Civil space activities have since created the "global village" concept and provided for a widening awareness of the global environment. According to Diebert (2003), two broad constraints limited the use of Earth remote-sensing technologies during the Cold War: national security and natural resource sovereignty.

Diebert suggests that these constraints have gradually dissipated with an accompanying proliferation and expansion of uses of space-based remote sensing technologies.²³⁷

Public funding for civil space programs at present still outweigh that of the private sector and as such ‘public good’ outcomes have driven civilian EO applications toward environmental monitoring and understanding human-environment interactions on a global scale. While the history of remote sensing and space technology development has clearly shown the value and need for international collaboration, the development of satellite monitoring capabilities that offer global transparency and democratized access to information about resources and human activities provides a very different form of governance than that which has existed for much of human history, a form of governance that has thus far been resisted by states due to competition that is embedded in traditional territorial and economic notions of sovereignty.

An emerging inability for states to maintain a monopoly over information collected and distributed by satellites may actually improve the opportunities for cooperation between disparate groups, processes characterized by increased global transparency, trust, cooperative gain, knowledge-sharing and the furthering of trans-national societal relations. In this sense, and possibly unpredictably, military hegemonies have been undermined by their own economic liberalization, perhaps resulting in a cultural shift within developed countries to an appreciation of concepts of security that are founded on economic principles rather than those reflecting territorial protection. In its transition from a technology of surveillance to a tool for science in the public realm, EO has provided insights into previously unknown ecological systems and has enabled the re-visualization of the Earth in its many interconnected dimensions, both biophysical and socio-political. The influences of the characteristics of EO including its inherent ‘transparency’,

²³⁷ Diebert, R., p.90 in Lambright (2003)

‘globality’ and perceived scientific ‘objectivity’ are likely playing some role in redefining traditional notions of sovereignty as it operates at the intersection of sovereign territory and the global commons.

Space commerce is becoming a global activity, and international organizations play an increasingly important role in shaping it. The public is less aware of these organizations than their national space agencies such as NASA or CSA because they are generally specialized technical agencies of the UN, for example the International Telecommunications Union (ITU) for allotting spectrum and orbital slots for regulating communications and GPS, the World Meteorological Organization (WMO) which influences data policies of space-based weather monitoring systems including encryption and user fees, the World Intellectual Property Organization (WIPO) which develops rules for protecting intellectual property such as software and databases, and the World Trade Organization (WTO) which governs trade disputes, subsidies and market access.

Space-based monitoring of the Earth environment has enabled a great deal of international cooperation between states, based largely on the epistemic scientific community that has bridged politics and cultures by identifying technical evidence of global environmental change. Civilian EO therefore takes place within a web of multilateral regimes that include the Committee on Earth Observation Satellites (CEOS), the Earth Observation International Coordination Working Group (EO-ICWG), the Center for International Earth Science Information Network (CIESIN), the Global Terrestrial Observing System (GTOS), and the World Weather Watch (WWW) of the WMO. Each regime is in turn coordinated through the Integrated Global Observing Strategy (IGOS) of the UN EarthWatch Program.

Regimes are an important aspect of governance and international relations in the post World War II environment. Stephen Krasner describes regimes as: “Principles, norms, rules, and decision-making procedures around which actor expectations converge in a given issue area.”²³⁸ Regimes can therefore be seen as over-arching philosophies that provide structures to facilitate negotiation, agreement and ideally – cooperation. Regimes are, in essence, long-term modes of thinking about the world and not “organisations” themselves such as the UN, WTO, ITU or WMO. Rather, the “organisations” are established to further the philosophy of the regime. In the case of the international regime which governs the use of outer space, the overarching philosophy is founded on a common heritage approach that denies any one nation from dominating or placing weaponry in space, while prioritizing the common-good aspects of space development.

The growing number of multilateral regimes advocating a role for satellite monitoring networks in global environmental governance indicates a large-scale acceptance of this technology. A global EO system has been described as necessary for providing “the long-term measurements to determine the habitability of the Earth”²³⁹ and for managing Earth systems that support human life. Indeed, the purpose of NASA’s Earth Observing System (EOS) has been described as providing an unprecedented amount of environmental data using the largest data-handling system ever constructed. The WMO relies on EOS for much of its data on global climate change monitoring and has stated that despite the very high development and operational costs of such a system, the costs to society from continuing the present level of uncertainty about climate change are very much larger.²⁴⁰

²³⁸ Krasner, S. (1983), p.2

²³⁹ Litfin (1998), p.212

²⁴⁰ *Ibid.*, p.213

As of 1997, a total of 490 international science and technology agreements were in force in 76 countries and six multinational organizations were supporting cooperation in remote sensing and EO involving 32 remote sensing satellites of which Canada and the US were major participants.²⁴¹ Additionally, a number of multilateral fora now exist to further expand the role that EO plays in providing actionable information to verify international environmental agreements, of which “more than 240 global and regional environmental agreements address almost every conceivable aspect of the Earth’s biophysical system.”²⁴² Clearly these developments suggest that a large market exists for environmental monitoring, although the private-sector EO industry does not appear to be emerging to fill this global need.

Representative of the views within multilateral environmental organizations is the perception that sovereignty concerns have continued to take precedence over the enforcement of environmental treaties, with contracting parties unwilling to accept external verification. The use of remote sensing for verification faces this perceived challenge to state sovereignty, by requiring consistent and regular access to data and documentation at reasonable cost, with a guaranteed level of transparency within monitoring processes. This area of application of EO technology also struggles with the advantages and disadvantages of the ‘securitization of the environment’, noting that until global or regional threats from environmental change are perceived to significantly affect national and societal interests including economic outcomes, states are unlikely to accept strict enforcement of environmental treaties by third parties. Advocates of establishing satellite verification systems for environmental agreements have stressed a need for strengthened institutional arrangements to promote communication and coordination between space agencies, satellite operators, commercial remote sensing

²⁴¹ Wagner (1998), p.ix

²⁴² Sherbinin (2000) no pagination

constituencies and environmental policy makers in overcoming challenges posed by traditional state security planners and their perception that commercial EO technology poses a threat to state sovereignty.

EO development has been primarily undertaken as a unilateral enterprise by only a few highly developed powerful states which raises serious questions of legitimacy when hegemonic powers inform on international issues. Diebert (2003) provides numerous examples of US intelligence satellites providing imagery and data to the international community. The UN Special Commission on Iraq, peacekeeping efforts in Bosnia, International Atomic Energy Agency inspections, and the UN High Commission on Refugees offer but a few cases where international decisions were informed primarily by imagery from US satellites. Rather than ensure a balance of power, Diebert suggests that this situation may lead to an institutional imbalance and the devaluing of the multilateral regimes that the data goes to support. As Gupta (1995) has argued, “[global] balance in remote sensing capability could become as important a factor as a balance of power to make a bilateral accord workable.”²⁴³

Many have claimed that transparency seems inevitable with the emergence of a globally competitive and privatized commercial EO industry. The logic flow is coherent, but the institutional impediments to this transparency are great. Primarily the trappings of poverty in many states and the assertion of state-based regulatory controls over EO suggest that the technology will remain in the hands of powerful elites, with some promise that civil society groups will gain the technological capacity to open new networks for the use of EO. Other major impediments to global transparency may come from the increasing economic influence played by

²⁴³ Vipin Gupta (1995) “New Satellite Images for Sale” *International Security* Vol.20 No.1 p.111 (pp.94-125)

defence agencies during the early commercialization cycle for EO technologies which lends very little commercial sovereignty to the private-sector.

International coordination of EO could create networks of verification capacity within existing national institutions or regional alliances that incorporate the private-sector without a need for new international bureaucracies. Possessing a reliable verification capacity can provide autonomy to a regime, a fundamental component of sovereignty. Access to information and control of the knowledge generated also contributes to sovereignty. Legitimacy of an environmental governance regime requires recognition by a wider community that confers authority.²⁴⁴ Even though an international institution will necessarily respect the principle of state sovereignty, they can be effective in addressing global problems as shown by Keohane et al. (1993). To effectively contribute to global environmental governance, EO could help a regulatory regime to “create networks over, around and within states that generate the means and incentives for effective cooperation among them.”²⁴⁵

6.2 Privacy in the Commons: A Limiting Paradigm

At the center of the need for government policy control over EO technology has been territorial sovereignty assertion and economic considerations, but in an ironic twist, strong controls of the EO industry in the US have increased the political legitimacy of EO technology for nation-building, resulting in increased competition internationally and reduced long-term competitiveness for the US EO industry. The US remote sensing policy environment has exerted a substantial influence on the choices available to new firms, complicated by the US government

²⁴⁴ Litfin (1997) pp.173-174

²⁴⁵ Keohane et al. (1993), pp.24-25

role as regulator, primary customer, patron and competitor with private-sector EO companies.²⁴⁶

In addition, shutter control legislation hovers above all economic decisions regarding foreign and domestic investment in programs that rely on consistent data supply. Global environmental monitoring is one of the primary program areas which, while provided for as a global good by civil agencies such as NASA, CSA and ESA, has not yet found an independent market in the private sector.

In the US where the government itself has expressed the need and established the organizational and technical basis for obtaining high quality global imagery and mapping, the NGA has expressed its determination to secure the best available information in support of any activities of US and NATO forces. The US military's strategy to maintain an information edge means that it will hand-down to the public some lower resolution imagery and data, maintaining the best available for itself. On the other hand, the civilian space industry in the US has committed to the collection and dissemination of detailed global topographic information in the interest of science for the common good. These conflicting policies in the US have at least had the effect of spawning debate over the commons aspects of EO while this debate is only beginning to take place in Canada.

Privatization and commercialization of the EO industry may open up new networks of users of satellite imagery and data, but without limits placed on the ability of private actors to capitalize on common-pool resources such as the use of the biosphere and outer space, it may become a detriment to the provision of public goods in remote sensing. As Jeremy Rifkin (1991) has argued, "if the commercial enclosure and privatization of the commons is not reversed and placed in public trust... then no effective counterweight will exist to curtail the appetites of the corporate

²⁴⁶ O'Connell et al. (2001), p.xiv

sector for resource optimization.” Indeed there is little evidence to suggest that private firms would voluntarily temper short-term profit maximization to accommodate the long-term sustainability of the biosphere.²⁴⁷

Privacy, not transparency could be the ultimate outcome of opening up the commons to private interests. Most democratic governments have a legislated obligation to provide information to the public about expenditures and operations, but private corporations can conceal information very efficiently through laws protecting intellectual property and trade secrets which are wrapped into the economic sovereignty concerns of states. Opacity within government policies regarding shutter control similarly limits public knowledge of the uses of the space commons. In addition, many scientific researchers, NGOs and relief organizations have felt the squeeze of more rigid application of property rights, data access and pricing policies as private-sector EO companies increasingly conform to commercial distribution standards.

Developing countries are also still struggling with a lack of infrastructure, institutional knowledge and technical ability to utilize remote sensing data and imagery, even when it is provided under development aid agreements. From the marketing data for commercial remote sensing imagery, it could also be suggested that this technology and its information products aids “development” in terms of precision for profitability rather than for sustainable resource management and use. As Litfin (1997) describes:

Even when information is made available at no cost to developing countries, which is by no means always the case, remote sensing is still a technology that is likely to benefit industrialized countries the most. Research agendas are largely set in the West, space and computer technologies are owned by the North, and the results are published in English. When satellite data reveals mineral deposits in Third World countries, US and European multinational corporations quickly arrive on the scene to “develop” the resources.²⁴⁸

²⁴⁷ Rifkin (1991), p.314

²⁴⁸ Litfin (1997) pp.26-47

As David Rhind (1999) has explained in the Canadian context, there seems to be “little real incentive to expend considerable financial sums on re-creating mapping ... onto a basis which facilitates regional or even global activities.” Thus, certain national commitments are being left to private enterprises through market forces, with the potential for the continued marginalization of underprivileged groups who most would benefit from the environmental and sustainable development applications of remote sensing satellites.

While access to remote sensing imagery was once confined to a limited number of countries at large cost, access is growingly global with civilian sources of data such as Landsat often available at the cost of reproduction. Despite this, use of the technology is still largely dominated by highly trained experts within defence and intelligence organizations, large resource-based corporations, Western governments and in commercial sectors such as real estate, insurance and oil, gas and mineral exploration. For private-sector EO firms, the attractions of being a safe government contractor can be a strong incentive not to risk change. As Scott Pace (1999) has described for the EO industry in the US, “the United States has not done much internationally to advance its traditional support for the free flow of information and to promote greater global transparency by private means.”²⁴⁹ Rapid evolution of information technology is democratizing the use and availability of remote sensing technology and products but the process of democratization is taking place within an existing political economy that serves the technological elites of both the public and private-sector spheres.

According to the CSA, “almost all remote sensing satellites are defined, developed and launched by governments or by private companies relying heavily on government support”, a situation the CSA claims is the case in Canada, Europe, Asia and in parts of the US industry. A key reason for

²⁴⁹ Pace, Scott. pp.77-78 in Lambright (2003)

this according to CSA is that there has not been sufficient growth in the number of users to pay for development costs and for operating systems, and applications remain too fragmented and specialized to generate low enough cost to revenue ratios. Discussions with marketing specialists at RSI confirm this phenomenon, with certain of their customers representing an overwhelming segment of the market for RSI, a potentially unhealthy situation for a mature business, but apparently not unusual at this stage of commercialization. The CSA has explained that EO business models need to change toward operational services, with demands moving from descriptive to predictive information products.²⁵⁰ But the marketing strategies employed by each of the four commercial EO firms analysed above show little acknowledgement of this need, preferring to consider themselves largely as data providers and demonstrating the ‘gee-whiz’ aspects of remote sensing to entice customers. With the CSA emphasizing that the global EO industry is only at the stage of semi-commercialization marked by continuing government intervention, it is clear that remote sensing business models will become less government-driven in the future and perhaps less responsive to civilian agency preferences for societal-needs-driven applications to be developed over the exploitation of profitable military and technology markets.

Many examples exist where governments steward certain important national industries and technologies with public funding, policy guidance and regulation transferring the self-sufficient operation of these industries to the private realm when they reach a level of maturity such that the national and common public interests are seemingly maintained. The kind of private-public partnership being pioneered by Canada for RADARSAT-2 is an example of this paradigm, but revenue shifts to the private sector may also be accompanied by an applications shift, particularly in the Canadian context where defence applications for EO have not been pursued domestically in

²⁵⁰ CSA (2003a), p.32

any substantial way due to the primarily civilian nature of space programs and satellite missions. In the US case, military EO programs are beginning to purchase their imagery and geospatial products from the private sector instead of managing their own independent systems.

To ensure profitable economic outcomes for major national industries, the private sector has been given the freedom to pursue global commercialization – a logical choice as corporations operate primarily by a profit motive. But by allowing industries that rely on common spaces to be run privately, a series of complicated issues arise, including whether common good benefits will be prejudiced to the profit motives of globally competitive industries. With the proper initial trajectory established by civil EO programs that prioritize environmental governance and public needs, private sector firms can emerge to commercialize these areas and maintain them. A vague market however may cause private firms to go wherever there is a substantial profit motive. John MacDonald, Chairman Emeritus of MDA has noted publicly that “a customer is a customer” to his company, and thus the commercial space sector does not concern itself with whether the applications of its products were peaceful or non-peaceful.²⁵¹

Other industries that make use of ‘the commons’ have reached a degree of privatization with government oversight aimed at ensuring common good benefits are maintained. Shipping on the high seas is a privatized industry regulated by international and domestic laws. National railways and aerospace industries have become privately run enterprises. Some road networks are becoming private ventures and the automotive industry which has an overwhelming impact on the commons through greenhouse gas emissions and other impacts has long been private-sector driven and heavily subsidized by states. The space industry is now shifting towards this paradigm

²⁵¹ John MacDonald, as quoted from Conference Report, “Safeguarding Space for All: Security and Peaceful Uses” 25-26 March 2004, Geneva.

as well, with satellite operation regulated as far as launch, object registry, orbit placement, broadcast frequency allotment and shutter control are concerned, but with varying degrees of freedom emerging for the application and use of EO technologies in the global marketplace. Of increasing concern to those relying on EO to provide common good benefits such as environmental monitoring, resource governance and sustainable development planning is that corporations do not have a history of providing benefit to the public good. In spite of Adam Smith's theory of comparative advantage that suggests the 'invisible hand' of the market will sort out any inequities in the system, the diffusion of public goods through global economic forces is likely to be vastly uneven.

The powers of EO can purportedly help to preserve the Earth's biosphere while furthering global liberal democracy. As Diebert (2003) has described for EO, "prevent[ing] the centralization of these technologies in a single node through dispersed control"²⁵² will be necessary to fully harness the power of EO to inform on global governance issues. The private-sector and the global economy loom as the conduit through which this trend may appear, but it is not assured. Policy debates over space commerce reflect deep conflicts between public and private sector interests. Globalization of the economy enables capital to flow where it finds the most inviting home. Intelligent governance rather than oppressive controls are therefore needed to adequately balance competing interests, set stable and predictable policies and ensure that actors in the private and public realms faithfully adhere to such policies. The emergence of a private-sector EO industry that depends on *global* markets and financing means *international* rules, not just *domestic* ones should determine how the uses of this technology are governed.

²⁵² Diebert (2003) p.90

6.3 Political Economy of EO – Information as Security?

According to modern economic theory, it is human capital and its ability to innovate that will be the key production factor of the new economy.²⁵³ But globalization of the space technology sector has facilitated the consolidation of this industry under the control of a few major corporations that form a substantial component of the military-industrial complex in the US. Lockheed-Martin, Northrop-Grumman/TRW, Boeing, and Raytheon have largely built and launched the satellites for private EO companies. In Canada, MDA and RSI are the major players in the EO economy. In as much as these companies derive the substantial portion of their revenues from the defence industry in the US, this uneven influence limits the kind of transformations that can occur through globalization.

The blurring of public and private sectors in the EO industry can be seen through various commercial and operational agreements forged between state governments and major technology firms. To cite another example of this, the NRO and the National Security Agency (NSA) elected to outsource to Raytheon much of the intelligence processing for Buckley Air Force Base in Colorado, the largest electronic intelligence downlink base in North America. In August 2002, Raytheon announced a billion-dollar expansion at the same site to develop ground systems for the National Polar-Orbit Operational Environmental Satellite, a joint weather-satellite program of the DoD, NASA, and NOAA.²⁵⁴ Private-sector multitasking represents the norm in the EO industry and the Canadian privatization of RADARSAT to be operated by MDA – another major military contractor – is yet another example. While the aerospace industry may not be powerful enough to establish a wider global trend on its own, the implementation of free markets serving large corporations does not seem possible without the support of large US defence budgets.

²⁵³ “Economic Growth—Explaining the Mystery”, *The Economist*, Vol. 322, No. 7740, p. 15-18

²⁵⁴ Wirbel (2002), p.2

The first justification for spending money on defence is to meet the needs of the military, but defence research and development activities do have other macro-economic implications.

Technological competitiveness is seen as a key element of discourses on national security in both the US and Canada although advances in defence technology is considered more important as an overall theme influencing US security. While history and recent statements by the Government of Canada suggest, defence research can be a key element of a national innovation strategy.²⁵⁵

As Wirbel (2002) has suggested, a technology base involving several national governments and corporations may yet emerge from the influence of military budgets but reliance on a “unilateralist and empire-building US military as a transitional source of funds for commercial ventures in space, however, may place space proponents in the Faustian position of supporting preemptive warfare technologies.”²⁵⁶ The overwhelming role played by large US corporations in building space systems that prioritize the needs of military agencies increasingly supports the unilateralist posture of US space policy.

A future world democratized by openly available geographic data about any place on Earth was envisaged in Al Gore’s vision of a Digital Earth. Open-ness through increased market competitiveness has, however, been tempered by policies on data access and a persistent government interest in protecting important national industries through subsidies provided to corporations. As such, the political economy of the commercial EO industry appears to support the sovereign goals of the state and the technological elite rather than the provision of routine Earth monitoring for global governance and sustainable development planning.

²⁵⁵ Government of Canada, *Achieving Excellence*, op. cit., p. 90

²⁵⁶ Wirbel (2002), p.3

Numerous claims have been made that unrestricted global access to EO imagery and data would have security implications for the US, particularly to its epistemological power. Threats have been constructed around the potential for terrorist groups to access satellite imagery and plan attacks, but the cognitive appeal of Earth imagery that conjures up notions of ownership and control may have more to do with state insecurity over a loss of territorial sovereignty. As such, remote sensing policy debates have focussed on the important role of states in protecting EO data. Remarkable emphasis has been placed on the knowledge-conveying power of satellite imagery with very few questions raised about the ability for such images to also obscure information or provide selected knowledge to serve special interests.

Significant scientific analyses of the threats posed by commercial satellite imagery to state security have concluded that minimal risk exists for terrorists or other adversaries to have the time, resources, finances, technical ability, willingness or need to utilize satellite imagery to carry out hostile activities. A recent study by Baker et al. (2004) clearly demonstrates that freely available geospatial information even at high resolution does not pose any significant threat to state governments. Indeed, weapon design plans can be studied in books and on websites, commercial air-liners can be turned into weapons of mass destruction when flown into buildings, GPS coordinates can be communicated by email or by satellite phone to a remote location for programming into a portable missile launcher, and each of these types of information is freely available in the public domain. There is no apparent reason why wide dissemination of EO data would be of concern to national governments apart from their own traditional desire to maintain territorial autonomy, commercial sovereignty or epistemological dominance. Satellite imagery is only one source of data among many. The only profoundly different aspect of EO technologies

compared to GPS or telecommunications satellites which are governed internationally is the immediate visual and cognitive appeal of Earth imagery.

Wider dissemination of satellite imagery as a public good may in fact do far more for enhancing civil-society governance than it will for enhancing state-based governance. With cheap available access to the world's EO satellites, NGOs could respond quickly to sudden humanitarian emergencies and could document and publicise important global or regional issues. A political economy of EO that supports this form of power transition from the corporate security state to the public realm is not likely to emerge within the currently dominant territorial formulation of security and sovereignty discourses.

6.4 Rethinking Security: a Global Commons Approach

The technology of Earth observation from space, it has been argued, is a strategic enabler for decision-making on a global scale. The dual-use nature of space and EO becomes clear when the 'enabling' abilities of such technologies can be to both improve human livelihoods through environment and sustainable development planning, and for marginalizing life through the maintenance of societal inequalities or for the locating and destruction of military targets. While it is not surprising that certain groups will conceptualize space according to their dominant cultures, the influence of military discourses of security that support the notion of 'space control' may compromise civilian notions of space as a peaceful sanctuary of the global commons.

Military strategists may be quick to point out that space has never been a peaceful sanctuary, and that international laws governing space do not explicitly limit its use for military means. But a paradox exists in the competing and contested security discourses revealed in this research concerning EO satellites: the applications of EO, whether for environmental monitoring, locating

natural resources for economic outcomes or for political and military purposes all emerge from the same basic quest for human survival, a principle that can be applied to both individuals and systems. In the system configuration, the notion of security becomes bifurcated, producing the two discourses of biospheric security and state security. These two discourses have resulted in competing efforts to develop EO technologies to monitor the Earth – one pursuing biospheric security which is maintained largely by civilian space programs with a degree of international cooperation. The other – supporting state security in a territorial and economic sense – has latently influenced the activities of the private-sector EO industry. The two discourses appear dischordant with each other and often overshadow the individual configuration of security.

Security's reconfiguration into various forms may serve to de-hinge the traditional role of the state in protecting the individual security of citizens, particularly when one considers the trans-boundary nature of global problems such as climate change or resource sustainability. The irony of national security is of course that war-planning and unsustainable economic growth produce insecurity. Steven Bardwell (1982) suggested the following conceptual reconfiguration of national security which appropriately summarizes the issue:

Real national security rests on economic growth, technological development, and human advancement that simultaneously provide a strong military and the objective self-interest that make war unlikely, if not unnecessary. A country producing new resources (rather than fighting for old ones), educating and training its population (rather than being plagued by unemployment...), and providing a hopeful future for its people, is a country with real national security. These are also the prerequisites for a military establishment committed to national development, technological innovation, and peace-winning.²⁵⁷

In considering the competition seen now between the private-sector, military planners and civil groups in undertaking EO missions, an analogy to the 'tragedy of the commons' can be envisaged,

²⁵⁷ Bardwell, S. (1982) 'The Science to Prevent Nuclear War' *Executive Intelligence Review*, Special Report, July issue.

where each actor seeks maximum control or market share of outer space and information dissemination to pursue their interests. With coordination of EO efforts through a convergence of discourses on securing the Earth, maximum gain to collective security and individual well-being might be a possibility.

Recognizing that securing healthy ecosystems as at least an underlying architecture for both the economy and territorial concerns is one means by which policies can perhaps be harmonized, but as seen in the forgoing analysis, environmental issues represent a far lower market share than do traditional security concerns. Currently the trend is that economic and territorial sovereignty concerns dominate the EO policy debate over other alternatives, and US policies are beginning to also dictate the formulation of Canadian approaches to EO governance.

Sovereignty, while taking on different forms in a global economy, is a concept that still involves rights and responsibilities in addition to power, control and autonomy. The concept has been traditionally linked to states but is growingly applied to corporations and even consumers as their power to control global market processes is increasingly felt. Sovereignty and private property may in fact be similar constructs, revealing why a private-sector EO industry has much in common with state interests in territorial and economic security. Global problems such as climate change seem to require policies and technologies such as EO that are operated by sovereign groups possessing adequate ability to govern and influence human behaviour. But the actors involved in responding or adapting to global problems are ultimately small groups and individuals whose participation is only sought in diffuse ways through regulatory measures. Human self-interest, lack of awareness and the ‘othering’ of responsibilities to governing bodies provides the

basis for sovereignty to be maintained in the state-level and private-sector corporate board-rooms of the world.

Concerns about the narrowing divide between civilian and defence agencies in their uses of space technologies are well founded theoretically, and a clearly distinct historical mandate for each continues to raise concerns over the militarization of the space commons and the continued securitization of the environment to serve specific territorial interests. On one hand, collaboration between these traditionally disparate groups (civil/environmental and defence/intelligence) is a good thing, as disciplines come together and the experts of each contribute to holistic solutions, combining both resources and thinking. But this liberalization of the defence sector to include such security mandates as the environment cannot be seen as a static event. Militaries respond to world events much more rapidly than global environmental policy has responded to environmental threats. Acceptance of closely linked mandates and platforms for environmental monitoring and military surveillance over the long-term could continue to threaten the sovereignty of civil groups to conduct studies and develop policy where the need is greatest.

Globalized access to EO and geospatial data of the Earth may provide a conceptual space for commons-based governance approaches to evolve, commensurate with a convergence of security discourses to be based on humanitarian and environmental concerns. The public imagery community is in the process of defining the skills and talents required for imagery exploitation to take place in the information commons. In the long term, it may be anticipated that these skills and practices may become diffused throughout the public policy community, to the point that civil society groups may routinely use satellite imagery to inform and influence public policy, gaining a sovereign voice for non-state, non-corporate discourses on global security.

7.0 POLICY PRESCRIPTIONS AND REGULATORY OPTIONS

Policy changes are not incremental, but rather occur rapidly at key points, in response to key events or technological discoveries. The events of 9/11 represent a focusing event – an unexpected, dramatic occurrence that lead to a dramatic change in the tone of public, media and government discussions. Canadian policy respecting commercial remote sensing space systems emerged through the urging of the US Government in response to high resolution satellite imagery becoming available from Canadian and international EO systems. The accumulation of knowledge is another means by which policy changes come about. In this case, the cumulative knowledge about humanity’s environmental impacts to the Earth may challenge policy makers to balance the application of EO technology that serves economic or territorial sovereignty purposes with the need for global environmental monitoring information and governance. The following paragraphs describe the need for suitable regulations to guide the private-sector EO industry and suggest some basic policy prescriptions that could be considered. In addition, a brief discussion is provided about the need for an appropriately-scaled regime to be enacted to implement policies respecting the global use of EO technology.

Market-driven governance appears to be the default global regime with respect to the activities undertaken by private-sector EO firms. This system is driven by producers and consumers along

the supply chain, with national governments left to guide and support the process domestically. Private-public partnerships, as seen historically in the Canadian EO industry, represent a form of shared governance whereby the government remains ultimately in power, but downloads some of its authority to multi-stakeholder groups for policy control and formulation. International governance, with states as primary actors, is yet another form of control structure that could be used to guide the activities of any space-faring actor.

Due to the predicted growth of commercial EO markets, the growing role of the private-sector and the changing nature of sovereignty, governments have been pursuing policies that reflect their national and regional interests that include the need for private industry to sustain national economic growth and technological capacity. Global competition in EO has made it imperative for Canada and the US in particular to be efficient in research and development efforts, reducing existing perceived overlaps between civilian and defence programs and linking EO mission priorities wherever practicable. In this formulation, a need for global environmental governance is always trumped by national economic needs, and in turn, economic interests are normally trumped by traditional territorial security concerns. Due to large budgets and growing dependencies that defence and intelligence agencies seemingly have on Earth imagery providers, regulations and policies governing remote sensing space systems are not adequately prioritizing the provision of common good applications by the private-sector.

US security discourses have always strongly influenced Canada partly due to each country's traditions as liberal democratic powers, but primarily due to geography and economics. As US military policy has turned toward the notion of 'space control' for its perceived national security needs, its well-developed EO policies governing commercial and private-sector activities have been

adjusted accordingly. These policies have not been adjusted to reflect the growing need for international knowledge and response to environmental and human security issues. US dedication to its own national security and its huge economic and technological power makes it a very unequal partner in global governance or in bilateral relationships. Canadian policy development respecting commercial EO that almost directly follows the trend established by the US faces the same strategic dilemma Canada has long faced in balancing the ‘security’ and economic needs of its citizenry. Unfortunately, Canada’s EO policy appears to maintain a traditional notion of security as the territorial protection of the state and its official policy makers.

As previously discussed, how states interpret their sovereignty and security interests becomes a primary driver of policy development regarding commercial EO. These interpretations in the US and Canada have been widely influenced by geography, history and the growing integration of the two economies. As Fergusson (2000) has explained, “Canada will have no choice but to accept the outcome of the US policy debate on space control.”²⁵⁸ Canada does, however, have the option to fight for its own interpretation of its national security, choosing to pursue a humanitarian discourse over the economic or territorial formulations that are traditionally understood by policy makers.

Recent revelations about the deteriorating health of the global environment suggest that EO is a most appropriately-scaled technology to inform on issues such as climate change and human-ecosystem vulnerabilities. For this reason alone, the scientific underpinning of EO technology that can reveal environmental problems can be used to trump narrow economic or military discourses on security that may either pursue unhelpful technology-driven approaches to EO development or restrict wide public dissemination of Earth information arising from commercial EO.

²⁵⁸ Fergusson (2000), p.49

Space science has always been an international effort for Canada and its EO industry would never have succeeded if it had not been globalized at an early stage. Canada's capacities in space are similar to many other middle-power space-faring nations in that it lacks observation platforms in many key areas, while possessing a wealth of data and experience in others. This situation will continue to require Canada to develop strategic partnerships internationally to exchange data and expertise. International collaboration is therefore key to all but a few states in deriving useful scientific information from EO systems.

Global monitoring of the Earth for environmental and sustainable development applications has largely been led by the US civilian space program. The merging of civilian, military and private-sector interests in the US, together with its global interests, has presented situations in which the US has elected to employ its EO systems for purposes with which partners do not wish to be associated, or which denies use of these systems outright. The overwhelming influence of US policy and the unbalanced partnering of other states or groups with US programs therefore do not seem to be in the best interest of global approaches to EO.

Science should become the strongest driver for normative regulation within the private-sector EO industry, with domestic policies and international guidance articulating a need for scientifically-informed responses to global environmental change. Science-driven programs in the long run will accrue more benefits to individuals, nations and the global community than alternative programs guided by short-term benefit motives.²⁵⁹

²⁵⁹ "A Window to Space – Canada's Space Environment Science: Principles and Recommendations" (Banff: Conference document) Oct.11-14, 2000

Over the years, strong efforts have been focused at controlling the negative aspects of EO on an international basis but existing inequities between states and the perception that EO advancement increases state power drives the desire for states to acquire their own EO capability. Despite the growing international coordination between civilian space agencies and the increasing potential for governments to have their requirements for EO met by commercial sources, countries may have become influenced by the territorial security discourse within the EO industry, leading to justification for pursuit of national satellite monitoring programs and infrastructures, a wasteful proposition when shared development offers a more effective framework for cooperation and global governance. The gain from a states' perspective is their exclusive and secure access to data, particularly for military use, and the near-real-time local reception of data. The gain from the private EO sector's perspective is the global expansion of markets, propelled by a perceived need for states to establish their own sovereign EO programs.

Governments and corporations in virtually every region of the world have invested in indigenous remote sensing industries and the necessary technology and support infrastructure has become global. It is unlikely therefore that any one national policy regardless of its market share will be able to control access to high-resolution satellite imagery. Therefore, US, Canadian and other governments will have to accept a new era of mutual assured observation and take advantage of its positive effects through forming intelligent policies while engaging in international cooperation to mitigate against unilateral strategies of space control, denial, deception or inequitable access to data. Confidence-building and crisis management strategies need to be addressed not just by space-faring nations, but by all groups and stakeholders in the EO industry.

Smaller nations have rejected policies that curtail their economic or strategic opportunities to develop or acquire technology. A major criticism of export control agreements by developing countries is that developed states seem to be steadily increasing their production or reliance on strategic technologies while requiring that developing countries maintain the status-quo and reliance on more powerful nations. In many cases, multilateral export control regimes are seen to promote technology limitation in the developing world that serves the interests of unilateral supremacy. States with stronger capacity to influence such regimes can be very effective in producing favourable markets for its own domestic industry.

Governments want to open up commercial markets for EO, but want to remain in control of policy to guard against unwarranted concerns over negative impacts to national security. The economies of scale in the space industry make it unlikely that scores of space programs in many countries will survive, and existing private-sector firms will maintain their reliance on state-sponsorship that biases the needs of military and defence agencies. A truly progressive, independent, science-based and peace-oriented regime that furthers a notion of national and international security based on commonly-shared needs is one way forward that can unite the disparate uses of EO arising in small civil programs and in the private-sector. Such a regime can be forged upon the basic premise that Earth observation from space is an activity that should be accountable to the commons.

Multilateral regulation of the EO industry not only seems possible because of the trend established for weather and telecommunications satellites, but also necessary because of geophysical realities and economic circumstances that make any satellite monitoring inherently a global enterprise. In addition, multilateral regulation involving multiple stakeholders is politically expedient and establishes trust based on commonly agreed-upon scientific understandings. While such a

multilateral regulatory body has been envisaged and proposed on numerous occasions by many groups, the emergence of a market-driven commercial EO sector provides a new impetus to advance the notion of a global regime.

To start moving in this direction, states can be encouraged that ‘security’ for their own space systems and programs is best pursued through the provision of goods and services to a global monitoring effort. By the introduction of a series of partial, prudent and concrete measures designed to bring about greater security in the environment in which states and private actors carry out their commercial space activities, it can be seen as both desirable and possible to get EO programs to observe a minimum of rules in the interests of a common objective – favouring *peaceful* utilization of space to secure the Earth’s environment and mutual inhabitability.

States can be urged to define precise rules of conduct for EO operators, and reaffirm the fundamental principles of international space law. A more stable international market for EO, decreased global economic and development gaps, and increased global civil security can be articulated as goals. No over-riding layer of international bureaucracy would need to be created as the laws and norms for peaceful space development largely exist.

Civilian space agencies could act as interagency brokers, tasked with forging synergy between foreign policy interests and private-sector EO firms. States could also ensure that government departments under their own jurisdictions are not working at cross-purposes on prioritizing the global-good aspects of EO. As seen in the comparison between Canadian and US remote sensing industries, reducing overlaps in departmental mandates and removing barriers to interdepartmental cooperation can provide the kind of efficiencies and institutional governance needed to undertake global projects.

Many governments in partnership with universities and NGOs are developing geospatial data clearinghouses to assist the sharing of geospatial data and to reduce overall data costs and maintenance. Data sharing through the Internet in support of public decision-making, education and research has primarily been seen as a triumph of the information commons and provides a model for state governments to follow in supporting global-good applications for private-sector EO. One international example worth noting is the UN Global Map Project, involving the participation of 80 countries as of 2000. The project was formed in response to Agenda 21 commitments made by states at the 1992 UN Conference on Environment and Development in recognition of the value of widely disseminating reliable geospatial information to directly address global environment and development problems.

In providing an overarching regulatory framework for commercial EO development, multilateral governance may be ultimately desirable but governments will have to reinforce the principles of corporate social responsibility that act as a self-governing regime for private-sector EO firms. ‘You shall’ style regulations can create markets and encourage innovation in a particular sector as seen on numerous occasions including mandated increases in fuel-efficiency in the automotive market. The discourse on national security can be expanded by states to encompass individual and global concerns such as human well-being and environmental sustainability. Through enlightened government policies on EO, the enterprise of global monitoring from space can be placed in the context of exactly what is at stake for the planet if we don’t obtain the information needed to respond and adapt to global issues.

From the above discussion, a series of policy recommendations and regulatory options emerge for states, EO firms and other groups. For states, it is suggested that a Typology of Responsible Use be

incorporated into all national policies respecting commercial EO and remote sensing, along the lines suggested by Helen Couclelis, Michael Goodchild and others for the geospatial information industry in general. Industry groups such as the American Institute of Aeronautics and Astronautics (AIAA) have themselves proposed certain ‘rules of the road’ that might be appropriate in increasing a user-base for the EO industry concerned with sustainable development and humanitarian formulations of security.

The following ‘rules of the road’ provide an initial set of elements that could be pursued by states or the private sector in forming a Typology of Responsible Use tasked with guiding EO development:

1. All satellite-based Earth observation activities shall be conducted in accordance with the legal principles established by international space law, formal treaties and global norms;
2. Satellite operators, geospatial data providers and value-added resellers shall conduct their business activities with the utmost regard to corporate social responsibility and conformity with domestic laws and regulations;
3. Commercial ventures in Earth observation and remote sensing shall be conducted with a high degree of transparency and public accountability in part by maintaining an openly available record of imagery acquisitions for which copies will be placed in a public archive;
4. The conduct of Earth observation activities shall be undertaken with the ultimate purpose of promoting trust and cooperation between other space-faring states and enterprises;
5. Satellite operators shall guard against the unilateral use and control of space and shall maintain a policy of peaceful-uses only for geospatial data and imagery products;
6. Earth observation activities shall support capacity building for global monitoring activities and in particular, support applications that increase global stability, transparency, environmental stewardship and sustainable, equitable development;

At an international level, all states, but particularly space-faring states should agree to an international statement on the permitted uses of commercial space systems that while recognizing the value of EO to commerce, clearly places environmental governance and sustainable development needs as a leading priority for national and commercial EO systems. Such a statement could also re-introduce the commons aspects of outer space by placing obligations and responsibilities on users to distribute the common benefits of their space activities to all.

Many related needs to strengthen the outer space regime could similarly be addressed by the international community to increase confidence in existing treaties and norms. Launch notifications, expanded access to information on the activities of space faring nations, education, mapping of the near space environment and increased dissemination of tools to help humanity visualize the ecological integrity of the planet could all be furthered by inter-state cooperation. States could incorporate their NGO and civil society groups including academics and commercial-sector representatives into the policy web that has traditionally taken place in closed government circles. In the US, Public Eye is an active NGO that seeks to utilize remote sensing imagery to further a humanitarian notion of global security. As yet, Canada has no public or non-governmental watch-dog to oversee the private-sector uses of EO technology. Links between technology, science and policy must be strengthened, taking advantage of the many existing structures that already exist for the global sharing of expertise and information.

An international treaty banning the overt military uses of space and forming a global Earth monitoring regime would be an ultimate objective, but a few of the necessary incremental steps toward these outcomes would be taken by states when prioritizing a humanitarian discourse on security within EO policies and in following some of the recommendations provided above.

8.0 CONCLUSIONS

This study has examined how satellite-based remote sensing technology has evolved as an important part of the Information Age, and how private-sector EO businesses in Canada and the US are marketing their geospatial data products. A comparison between discourses found in the civilian uses of remote sensing and the priorities reflected in the private-realm has been undertaken. Through the texts of official policies in Canada and the US, a review of economic trends in the EO industry, and a documentary analysis of marketing approaches pursued by several prominent private-sector EO firms, it has been shown that the commercial market for Earth imagery and data continues to be largely influenced by the sovereignty concerns of states as they remain the primary customers of their domestic EO systems despite the international scope of the imagery and data products. While the growing availability of Earth imagery and data may conceptually support an ecosystem approach to environmental policy making at various scales, emphasis within the commercial sector has thus far been placed on technologies and applications that support such ‘security’ applications as hard object recognition and territorial surveillance primarily suited for military and intelligence-gathering needs by state actors.

Remote sensing policies reflect a belief that EO technology can support the role of the state in supplying information for the ‘public good’, but at the same time offer a means to control and

monitor access to information, a traditionally important role of sovereign state powers. Security discourses conveyed through selected use of language and the visual and geographical concepts of remote sensing from space have been important in formulating public perceptions and general acceptance of a private-sector EO industry. The economic growth suggested for the global EO market suggests that the private-sector will increasingly influence policy development and discourses on security issues pertaining to the uses of EO. The visual appeal of EO may also increasingly provide users of the technology with the potential to influence alternative security discourses although at least some of the public interest in satellite imagery may derive simply from the novelty value of this unprecedented product. As this novelty value declines, some public interest may also decline which is why a commons-based regulatory framework may be needed.

Underlining much of the discussion above is the notion that modern technologies that provide humanity with a means of self-observation in near-real time do not merely suggest the power inherent in geographic knowledge but could represent a process of seductive entrapment that allows for the pursuit of modern descriptive technologies as a means of addressing problems over the exclusion of other alternatives. For over two decades, the US and Canada have encouraged the commercialization of remote sensing and EO technologies based on an assumption that private-sector growth in this area would synergistically contribute to national security and economic growth. International cooperation has continued in civilian EO programs and the various benefits of reliable, transparent and democratized access to EO data and products have largely been articulated by national governments and international organizations alike. The policies of both the US and Canada, and the formulation of various international organizations to pursue global monitoring from space have provided the potential for all of these goals to be satisfied, and yet these goals remain largely unfulfilled.

Economic competitiveness, states' preoccupation with national security and sovereignty as it relates to space industry prominence and territorial protection have largely created barriers to the wider dissemination of the valuable information products that could be made available by commercial EO technology for global environmental governance. Government subsidies have assisted the construction of national EO industries at the cost of resources and funding not enabling global monitoring systems and the widespread benefits of the technology. Opaqueness within these private-sector industries and the strong policy, applications development and funding interactions between private EO firms and military organizations complicate future planning for international cooperation in the peaceful uses of satellite technology for global governance issues. Public access to the information commons is further limited by the need for states to create viable geospatial markets for private EO firms that creates cost and access barriers to potential users.

The perception that political legitimacy, authority and control are integral aspects of national space programs has further engaged less-developed countries in the development of national EO industries, often when economic and human capital would be better placed elsewhere than in the narrow pursuit of sovereignty-enhancing outcomes. Commonly-pooled resources for EO could equally benefit rich and poor countries alike in addressing sustainable development and environmental governance needs. In order for overall public good benefits to be realized from commercial satellite remote sensing, national interests must be configured as congruent with the needs of a global population and a planet that is increasingly in need of information and knowledge that enables environmental decision-making and sustainable futures. The notion of 'security' is critical to this outcome in that defining the term narrowly in terms of the sovereign needs of state actors will continue to limit global common good outcomes. A wider notion of 'security' applied to humanitarian concerns, a sustainable environment, Millennium goals and

Agenda 21 commitments, and even the status of outer space as a peaceful commons is required to direct the long history of civilian space development towards the betterment of the planet.

The prospect for satellite technologies to support new thinking about global issues at appropriate scales may rely as much on the powerful cognitive appeal of Earth imagery as it does on the critical knowledge gained about human-environmental interactions that provides routine decision-support for a wide number of applications. The emergent private-sector EO market seems to be following a trajectory that returns the technology of satellite remote sensing to its original use as a powerful surveillance tool for nation states. If carefully shepherded by multilateral regulation that promotes the opening up of the global commons aspects of EO, a badly needed shift in perspective could move states from a strategic to a humanitarian discourse for global security.

It has been argued that the societal implications of remote sensing technology do not simply result from one application or one individual choice for its use, but from an array of institutional and ideological conditions surrounding the development of the industry itself. Technologies themselves do not change the world, but rather human beings, when they have the necessary incentives, skills and tools available to them, can re-visualize, rethink and remodel the world. The commercialization of this industry simply extends the societal reach of the ideologies, concepts and constructs inherent in this technology, making it even more important to democratize and diffuse the power over its use. It is clear that to usurp the malevolent potential uses of remote sensing and space technologies in general, strengthening existing multilateral institutions in the field of remote sensing is crucial. In addition, there is an emerging role for civil society to develop linkages at various scales, and emphasize a cooperative, democratic and global approach to the further development of space technologies. As this existing trend continues, (and hopeful

evidence that it will continue has been shown), there exists a strong sense that the philosophy of “the commons” is being supported by the use of spatial information systems and in particular, satellite-derived Earth imagery.

By privatizing services such as satellite remote sensing, governments follow a continuing trend among Western economic powers towards de-regulation of government-run industries including EO, ultimately downloading responsibility and authority to businesses that for the most part are expected to self-regulate through pricing policies, data standards and licensing. The transition to a private-sector driven EO industry represents a notable break with the past, now adding high-resolution satellite imagery to the growing list of information available in the global economy. What appears clear however from the above summary of prevailing policies is that governments are not prepared for the ensuing impacts. While some scholars of international relations have welcomed the privatization of national EO programs as a quantum leap forward in global transparency, government policies where they exist are focussed far too much on economic outcomes and not enough on how those economic outcomes are reached. While the historical US hegemony in satellite remote sensing may suggest that governments model their data access and commercial policies based on the US model, a wider perspective must be taken when considering the global need for continued and increased levels of environmental monitoring, ecological awareness and strategic locational information for environment and development policy makers wishing to forecast future scenarios for addressing global issues.

Within the field of global environmental politics, academics and policy-makers have begun to study the problems of capitalizing on the Information Age and the liberalization of the military and its technologies for use in global environmental research. Michael Krepon has suggested that

it would be “sensible to begin thinking seriously about safeguards against the negative applications of satellite technology and ways to accentuate the positive.”²⁶⁰ The role that the Information Age has on the decentralization of power structures will in turn have profound implications on how middle-powers such as Canada assert its sovereignty in a world dominated by US interests. As access to commercial satellite imagery and data increases, global transparency may support multilateral governance of the environment and other issues of global concern. While the commercialization of the space industry in Canada and the US poses some challenge to official policy makers in terms of surveillance and rights to privacy issues, the remote sensing industry can be guided by careful implementation of policies that balance sovereign needs with the need to build global cooperative efforts to serve the common good.

Lastly, the importance of one specific technology to assessing the long-term habitability of the planet must be understood through the other costs that it brings to bear on society and the global environment. Will the vast quantities of environmental information obtained through EO technology outweigh the economic and social costs of its development? Will knowledge gained through the processing of all of this information actually tell us how to live more sustainable lives, reducing resource throughput in the industrialized world? The answer to these questions will largely depend upon who uses and controls the information and to what purposes it is applied.

²⁶⁰ Krepon et al. (1990), p.31

REFERENCES

American Society for Photogrammetry and Remote Sensing (ASPRS). 2004. The 10-Year Industry Forecast. *Journal of Photogrammetric Engineering and Remote Sensing*, Jan. 2004.

Axworthy, Lloyd. 2001. "Introduction" in Rob McRae and Don Hubert (Eds.). *Human Security and the New Diplomacy*. McGill-Queen's University Press, pp.3-13.

Axworthy, Lloyd. 2003. *Navigating a New World*. Toronto: Alfred A. Knopf

Baker, John C., Kevin M. O'Connell, and Ray A. Williamson, (Eds.). 2001. *Commercial Observation Satellites: At the Leading Edge of Global Transparency*. RAND and the American Society of Photogrammetry and Remote Sensing.

Baker, John C., Beth E. Lachman, David R. Frelinger, Kevin M. O'Connell, Alexandra C. Horn, Michael S. Tseng, David Orletsky, Charles Yost. 2004. *Mapping the Risks – Assessing the Homeland Security Implications of Publicly Available Geospatial Information*. Santa Monica, CA: Prepared by RAND and the US National Defence Research Institute for the NGA.

Boland, Alana. 2000. Feeding Fears: competing discourses of interdependency, sovereignty, and China's food security. *Political Geography* vol.19, pp.55-76

Bulkeley, Rip. 1991. *Sputniks crisis and early United States space policy: a critique of the historiography of space*. London: MacMillan.

Canada Centre for Remote Sensing (CCRS). 1993 (updated 2004). The history of the development of the Canada Centre for Remote Sensing, as seen by Lawrence W. Morley, the first Director General of CCRS. Available at: http://www.ccrs.nrcan.gc.ca/ccrs/org/history/history_e.html

CCRS. 1976. *Surveillance Satellites and Complementary Airborne and Seaborne Surveillance Systems for Canada*. Don Clough and Archie McQuillan (Eds.). Report commissioned by the Interdepartmental Task Force on Surveillance Satellites, The Interagency Committee on Remote Sensing, the Interdepartmental Committee on Space and the Oceans Panel (Sept. 30, 1976).

Canadian Space Agency (CSA). 1994. *Canadian Space Policy Framework*. Ottawa: Government of Canada. Available at http://www.space.gc.ca/asc/eng/science_industry/policy.asp#1

Cleminson, Ron. 2004. "No Weapons in Space: Maintaining Stability and Security Through Arms Control" *International Insights – Canadian Institute of International Affairs Occasional Papers*, Vol.2 No.4. available at www.ciiia.org

CSA. 1999a. *Annual Review 1998-1999*. Ottawa: Government of Canada.

CSA. 1999b. *National Paper: The Canadian Space Programme*. Ottawa: Government of Canada.

- CSA. 2003a. Global Space Sector Market Trends and Drivers 2002. Ottawa: Government of Canada.
- CSA. 2003b. Earth and Environment: Significant Canadian Events and Achievements Report 2003. Ottawa: Government of Canada.
- CSA. 2004. State of the Canadian Space Industry 2002. Ottawa: Government of Canada.
- Chrisman, Nicolas. 1997. Exploring Geographic Information Systems. Wiley & Sons
- Colwell, R. N. 1997. "History and place of photographic interpretation" in Manual of Photographic Interpretation, W.R. Philipson, (Ed.). pp 33-48. Bethesda, MD: American Society for Photogrammetry and Remote Sensing.
- Conca, Ken. 1993. "In the Name of Sustainability: Peace Studies and Environmental Discourse" Proceedings: Conference on Environmental Change and Security, Vancouver, 1993, pp.9-19.
- Conca, Ken and Geoffrey D. Dabelko. 2002. Environmental Peacemaking. Washington DC: Woodrow Wilson Center Press.
- Cosgrove, Denis. 1994. "Contested Global Visions: One-World, Whole-Earth, and the Apollo Space Photographs". *Annals of the Association of American Geographers* 84(2):270-294.
- Couclelis, Helen. 1999. "Spatial Information Technologies and Societal Problems." pp.15-24. (Ch.2) in Geographic Information Research: Trans-Atlantic Perspectives. Massimo Craglia, and Harlan Onsrud (Eds.). London: Taylor & Francis.
- Crutzen, Paul J. 2002. "Geology of Mankind" *Nature* Vol.415 No.3 (January 2002). p. 23.
- Dalby, Simon. 2000. "Geopolitical Change and Contemporary Security Studies: Contextualizing the Human Security Agenda", Working Paper No. 30, Institute of International Relations, University of British Columbia, (April 2000).
- Dalby, Simon. 2002a. "Security and Ecology in the Age of Globalization". *Environmental Change and Security Project Report* no. 8, pp. 95-108.
- Dalby, Simon. 2002b. Environmental Security. Minneapolis, Minn: *Borderlines* Vol.20
- Dalby, Simon. 2004. "Anthropocene Ethics: Rethinking 'the Political' after Environment" Paper prepared for the Annual Convention of the International Studies Association, Montreal (March 2004).
- Dehqanzada, Yahya A. and Ann M. Florini. (Eds.). 2000. Secrets for Sale: How Commercial Satellite Imagery Will Change the World. Washington, DC: Carnegie Endowment for International Peace.

Department of Foreign Affairs and International Trade Canada (DFAIT). 1999. News Release and Policy Backgrounder: Developing a Canadian Access Control Policy for Commercial Remote Sensing Satellites. Ottawa: Government of Canada

Department of Foreign Affairs Canada. 2004. Space Security 2003. Prepared for the International Security Bureau of the Department of Foreign Affairs. Ottawa: Government of Canada.

Department of National Defence Canada (DND). 1994. 1994 White Paper on Defence. Ottawa: Government of Canada. Available at http://www.forces.gc.ca/admpol/eng/doc/white_e.htm

DND. 1998. Department of National Defence Space Policy. Ottawa: Government of Canada.

Deudney, Daniel H. 1992. "The Mirage of Eco-War: The Weak Relationship among Global Environmental Change, National Security and Interstate Violence." pp.169-191 (Ch.9) in Ian H. Rowlands and Malory Greene (Eds.) *Global Environmental Change and International Relations*. London: MacMillan.

Deudney, Daniel H. and Richard A. Matthew, (Eds.). 1999. *Contested Grounds: Security and Conflict in the New Environmental Politics*. Albany: State University of New York Press.

Diebert, Ronald J. 1999. Out of Focus: US Military Satellites and Environmental Rescue. pp. 267-288. (Ch.11) in *Contested Grounds: Security and Conflict in the New Environmental Politics*. Deudney, Daniel H. and Richard A. Matthew, (Eds.). Albany: State University of New York Press.

Diebert, Ronald J. 2003. see Ch.3 in Lambright 2003.

Dixon, Frank. 2004. Gross National Happiness: Improving Unsustainable Western Economic Systems. Available at <http://www.yale.edu/envirocenter/gnh.pdf>

Dolman, Everett C. 2002. *Astropolitik: Classical Geopolitics in the Space Age*. London: Frank Cass Publishers.

Dorn, Walter. 1987a. PAXSAT: A Canadian Initiative in Arms Control (Looking Out for Peace from the Sky). *Peace Magazine*, Oct/Nov (1987), pp. 17-18.

Dorn, Walter. 1987b. Peacekeeping Satellites: The Case for International Surveillance and Verification. Available at http://www.rmc.ca/academic/gradrech/dorn19_e.html

Edmonds, M. 1993. "Technology Dependence: The Hidden Side of Defence Research and Development", in Coopey Richard, Matthew Uttley and Graham Spinardi (Eds.). *Defence Science & Technology: Adjusting to Change*. Chur, Switzerland: Harwood Academic Publishers.

Escobar, Arturo. 1995. *Encountering Development: The Making and Unmaking of the Third World*. Princeton, NJ: Princeton University Press.

Fergusson, James. 2000. Thinking the Unthinkable: On Revolution, Outer Space and Canadian Policy. *Canadian Military Journal*, Summer 2000. pp.41-50

Florini, Ann M. 1988. Third Party Imaging Satellites and US Security. *International Security* Vol.13, No.2, pp.91-123.

Florini, Ann M. and Yahya A. Dehqanzada. 1999. No More Secrets? Policy Implications of Commercial Remote Sensing Satellites. Global Policy Program Working Paper Number 1 (July 1999). Carnegie Endowment for International Peace. Available at www.carnegieendowment.org

Florini, Ann M. and Yahya A. Dehqanzada. 2001. "The Global Politics of Commercial Observation Satellites" Ch.20 of *Commercial Observation Satellites: At the Leading Edge of Global Transparency*. John C. Baker, Kevin M. O'Connell, and Ray A. Williamson, (Eds.). RAND and the American Society of Photogrammetry and Remote Sensing.

Foucault, Michel. 2003. *Society Must Be Defended*. Translated by D. Macey. Lectures at the College de France 1975-1976. New York: Picador.

French, Hilary F., (Ed.). 1995. Partnership for the Planet: An Environmental Agenda for the United Nations. Worldwatch Paper No. 12, July 1995.

Futron Corporation. 2001. Trends in Space Commerce. Report prepared for the US Department of Commerce Office of Space Commercialization. Washington, DC.

Futron Corporation. 2003. 2001-2002 Satellite Industry Survey. Report prepared for the Satellite Industry Association. Washington, DC.

Glendinning, Chellis. 2002. *Off the Map*. Gabriola Island, BC: New Society Publishers.

Godefroy, Andrew B. 1998. Space and National Security: Canada's Sporadic Strategy, 1985-1999. Paper presented to the Conference of Defence Associations 13-14 November, 1998.

Godefroy, Andrew B. 2000. Is the Sky Falling? Canada's Defence Space Program at the Crossroads. *Canadian Military Journal* (Summer 2000).

Goldsen, Joseph. (Ed.). 1963. "The International Implications of Outer Space Activities" in *Outer Space in World Politics*. New York: Praeger.

Goodchild, Michael F. 1999. "Cartographic Futures on a Digital Earth" in Keller, P., (Ed.). *Touch the Past, Visualize the Future*, Proceedings of the 19th Conference of the International Cartographic Association, Ottawa, August (1999) Vol.1 pp.1-35

Gore, Al. 1998. The Digital Earth: Understanding our planet in the 21st Century. Keynote Address at the Grand Opening Gala of the California Science Center in Los Angeles (Jan. 1998).

Government of Canada. 2004. Bill C-25 (Nov.23/04) An Act Governing the Operation of Remote Sensing Space Systems. Ottawa: Minister of Foreign Affairs.

Gupta, Vipin. 1995. New Satellite Images for Sale. *International Security*, Vol.20, No.1 (summer 1995), pp. 94-125

Gutkind, A.E. 1956. "Our world from the air; conflict and adaptation", pp. 1-44 in *Man's Role in Changing the Face of the Earth*. William L. Thomas (Ed.). Chicago: University of Chicago Press.

Haines, Gerald K. 1997 *The National Reconnaissance Office: Its Origins, Creation and Early Years*. Chantilly, Va: National Reconnaissance Office.

Hall, Stephen 1993. *Mapping the Next Millennium: How Computer-Driven Cartography is Revolutionizing the Face of Science*. New York: Vintage Books.

Hampson, Fen. 2002. *Madness in the Multitude: Human Security and World Disorder*. Oxford: University Press.

Harley, Brian J. 1989. "Maps, knowledge and power" in: Denis Cosgrove and Stephen Daniels (Eds). *The Iconography of Landscape*. Cambridge University Press.

Harris R. and R. Krawec. 1993. Earth Observation Data Pricing Policy. *Space Policy*, Nov. 1993, pp.299-381

Harvey, David. 1993. "The Nature of Environment: The Dialectics of Social and Environmental Change." *Socialist Register*. Vol.29. pp.1-51

Heintze, Hans-Joachim. 1999. Peaceful Uses of Outer Space and International Law. Presented at the March 1999 Conference "Space Use and Ethics"

Hertzfeld, Henry R. 2002. *Space Economic Data*. Washington, DC: George Washington University Elliott School of International Affairs, Space Policy Institute, Dec. 2002

Homer-Dixon, Thomas. 1999. *Environment, Scarcity, and Violence*. Princeton: Princeton University Press.

International Geosphere Biosphere Program. 2004. *Global Change and the Earth System: A Planet Under Pressure*. Will Steffen and Susannah Elliott (Eds.). Berlin/Heidelberg/New York: Springer Verlag Publishers.

Jacob, C. 1992. *L'Empire des Cartes: Approche Theorique de la Cartographie à Travers l'Histoire*. Paris: Albin Michel.

Johnson, Dana J., Gregory H. Hilgenberg and Liam P. Sarsfield. 2001. Policy issues and challenges for interagency space systems acquisition. RAND Publications.

- Kaldor, Mary 2003. *Global Civil Society: An Answer to War*. Oxford: Polity.
- Keohane, Robert, Peter Haas and Marc Levy. (Eds.). 1993. *Institutions for the Earth: Sources of Effective International Environmental Protection*. Cambridge, MA: MIT Press
- Kish, John. 1973. *The Law of International Spaces* Netherlands: A.W. Sijthoff.
- Kline, Karen and Kal Raustiala. 2000. *International Environmental Agreements and Remote Sensing Technologies*. Background paper prepared for the Workshop on Remote Sensing and Environmental Treaties: Building More Effective Linkages, December 4-5, 2000
- Krasner, S. 1983. "Structural Causes and Regime Consequences: Regimes as Intervening Variable," in *International Regimes*, S. Krasner (Ed.). Ithaca: Cornell University.
- Krepon, Michael, Peter D. Zimmerman, Leonard S. Spector and Mary Umberger. (Eds.). 1990. *Commercial Observation Satellites and International Security*. Carnegie Endowment for International Peace, St. Martin's Press, New York.
- Kuehls, Thom. 1996. *Beyond Sovereign Territory. Borderlines*. Vol.4. University of Minnesota Press.
- Kurtz, Howard. 1957. "An Engineer vs. War" *American Engineer*. (Sept. 1957).
- Kurtz, Howard. 1969. "The Collapse of US Global Strategy". *Military Review*. (May 1969).
- Lambeth, Benjamin S. 2003. *Mastering the Ultimate High Ground: Next Steps in the Military Use of Space*. Santa Monica, CA: RAND Publications.
- Lambright, W. Henry. (Ed.). 2003. *Space Policy in the Twenty-First Century*. Baltimore: Johns Hopkins University Press.
- LaTour, Bruno. 1993. *We Have Never Been Modern*. Translated by C. Porter. Cambridge: Harvard University Press.
- LeDrew, Ellsworth, Murray Strome and Frank Hegyi, (Eds.). 1995. *The Canadian Remote Sensing Contribution to Understanding Global Change*. University of Waterloo Press Department of Geography Publication Series No.38.
- Lenczowski, R. E. 1997. *The Military as Users and Producers of Global Spatial Data. Framework for the World*. D. Rhind. New York, NY, John Wiley & Sons, Inc. pp.85-110.
- Lindsey, George. 1992. *Surveillance from space: a strategic opportunity for Canada*. Working Paper 44 Canadian Institute for International Policy Studies. (June 1992).

- Litfin, Karen T. 1997. The Gendered Eye in the Sky: A Feminist Perspective on Earth Observation Satellites. *Frontiers*. Vol. 19. No.2. pp. 26-47
- Litfin, Karen T. 1998. "Satellites and Sovereign Knowledge: Remote Sensing of the Global Environment" in *The Greening of Sovereignty in World Politics*, Karen T. Litfin, (Ed.). MIT Press, pp.193-221.
- Livingston, Steven and W. Lucas Robinson. 2002. Mapping Fears: The Use of Commercial High-Resolution Satellite Imagery in International Affairs. Prepared for the 43rd annual conference of the International Studies Association, March 23-27, 2002, New Orleans, LA.
- MacDonald Dettwiler and Associates. 2004. Earth Observation Systems brochure. Richmond, BC.
- MacEachren, Alan M. with Barbara P. Battenfield, James B. Campbell, David W. DiBiase, and Mark Monmonier. 1992. "Visualization" Chapter 6 in Abler, R.F. Marcus, M.G. and Olson, J. (Eds.) *Geography's Inner Worlds*. Rutgers University Press.
- Malo, Maj François. 1998. Canadian Aerospace Sovereignty: In Pursuit of a Comprehensive Capability. War, Peace and Security. <http://www.fas.org/news/canada/0056.htm#n13>
- Matthew, Richard A. 1999. "Conclusion: Settling Contested Grounds" in: Deudney, Daniel H. and R.A. Matthew (Eds.). *Contested Grounds: Security and Conflict in the New Environmental Politics*. Albany: SUNY Press.
- Matthew, Richard A. 2000. Environment and Security in an International Context: Critiquing a Pilot Study from NATO's Committee on the Challenges of Modern Society. *Environmental Change & Security Project Report*, Issue 6 (Summer 2000).
- Matthew, Richard A. 2002. In Defense of Environment and Security Research. *Environmental Change and Security Project Report*, No.8. pp.109-124
- Mau, Bruce (with Jennifer Leonard and the Institute without Boundaries). 2004. *Massive Change*. London/New York: Phaidon Press.
- McLucas, John L. 1985a. "Whither Landsat?" editorial in *Aerospace America*, Jan. 1985.
- McLucas, John L. 1985b. "Open Skies a Fresh Challenge" *Aerospace America*, Apr. 1985.
- Miller, Toby. 1993. *The Well-Tempered Self: Citizenship, Culture and the Postmodern Subject*. John Hopkins University Press.
- Moltz, James Clay. 2003. Reigning in the Space Cowboys. *Bulletin of the Atomic Scientist*. Jan-Feb 2003. pp. 61-66.
- Monmonier, Mark. 1995. *Drawing the Line: Tales of Maps and Carto-controversy*. New York: Henry Holt and Company

- Monmonier, Mark. 1991. *How to Lie With Maps*. Chicago: University of Chicago Press.
- Monmonier, Mark. 2002. *Spying With Maps: Surveillance Technologies and the Future of Privacy*. Chicago: University of Chicago Press.
- Moorman, Gen. Thomas S. Jr. 1999. The Explosion of Commercial Space and the Implications for National Security. *Aerospace Power Journal*. (Spring 1999).
- Morley, Lawrence W. and Don Clough, Eds. 1976. *Proceedings: International Symposium for Earth Observation and Environmental Control*. Plenum Press. Nov. 1976
- Morley, Lawrence W. 1993. *Remote Sensing Then And Now* (see Canada Centre for Remote Sensing, 2004)
- Mosco, Vincent. 2004. *The Digital Sublime: Myth, Power, and Cyberspace*. Cambridge: MIT Press.
- Naisbitt, John and Patricia Auburdene. 2000. *Megatrends*. New York: William Morrow & Co.
- National Geographic Video. 1989. *For All Mankind*. National Geographic
- National Research Council (US). 1977. *Resource sensing from space: prospects for developing countries*. Report of the Ad Hoc Committee on Remote Sensing for Development, Board on Science and Technology for International Development, Commission on International Relations. Washington: National Academy of Sciences.
- National Research Council (US). 2002. *Down to Earth - Geographic Information for Sustainable Development in Africa*. Report of the Geographic Information for Sustainable Development project (GISD, 2002). Washington D.C.: National Academies Press.
- O'Connell, Kevin M, John C. Baker, Beth E. Lachman, Steven Berner, David Frelinger and Kim E. Gavin. 2001. *US Commercial Remote Sensing Satellite Industry : an Analysis of Risks*. Report prepared for the US Department of Commerce. Santa Monica, CA: Rand Publications.
- Pace, Scott, Brant Sponberg and Molly Macauley, Eds. 1999. *Data Policy Issues and Barriers to Using Commercial Resources for Mission to Planet Earth*. Washington D.C.: RAND Corporation Publication.
- Paterson, Matthew. 2000a. *Understanding Global Environmental Politics*. New York: St. Martin's.
- Paterson, Matthew. 2000b. Car Culture and Global Environmental Politics. *Review of International Studies*, No.26, pp.253-270.
- Peet, Richard and Michael Watts. 1996. *Liberation Ecologies: Environment, Development, Social Movements*. New York: Routledge

Pickles, John. 1995. "Representations in an Electronic Age: Geography, GIS, and Democracy." pp. 1-30 in *Ground Truth: The Social Implications of Geographic Information Systems*. John Pickles (Ed.). New York: The Guilford Press

Pickles, John. 1999. "Cartography, Digital Transitions, and Questions of History." pp. 15-27 in *Touch the Past, Visualize the Future, Proceedings of the 19th International Conference of the ICA*, Vol.1. Keller, P., (Ed.). Ottawa, August 1999.

Radarsat International (RSI). 1999. *Radarsat Illuminated: a Guide to Products and Services*. Available at: http://www.rsi.ca/products/sensor/radarsat/rsiug98_499.pdf [accessed Oct. 29, 04]

Rees, William and Mathis Wackernagel. 1996. *Our Ecological Footprint: Reducing Human Impact on Earth*. New Society Publishers

Rhind, David W. 1999. "Business, governments and technology: inter-linked causal factors of change in cartography" pp. 29-35 in *Touch the Past, Visualize the Future, Proceedings of the 19th International Conference of the ICA*, Vol.1. Keller, P., (Ed.). Ottawa, August 1999

Sachs, W., Loske, R. and Linz, M. 1998. *Greening the north: A post-industrial blueprint for ecology and equity*. London: Zed Books.

Sadako, Ogata and Amartya Sen. 2003. Ch.5 of the Final Report of the Commission on Human Security. New York: United Nations. Available at <http://www.humansecurity-chs.org/finalreport/chapter5.pdf>

Samson, Paul R. and David Pitt, eds. 1999. *The Biosphere and Noosphere Reader: Global Environment, Society and Change*. New York: Routledge.

Sherbinin, Alex de, (Ed.). 2000. *Remote Sensing and Environmental Treaties: Building More Effective Linkages*. Report on the Workshop of the Center for International Earth Science Information Network (CIESIN), December 4-5, 2000. Woodrow Wilson International Center, Washington D.C.. Available at <http://sedac.ciesin.columbia.edu/rs-treaties>

Sherbinin, Alex de and Chandra Giri. 2001. Center for International Earth Science Information Network (CIESIN), Columbia University. Working paper for presentation at the Open Meeting of the Human Dimensions of Global Environmental Change Research Community, Rio de Janeiro, 6-8 October 2001.

Slaymaker, Olav. 2004. "Environmental Studies in Global Perspective: Who Cares?" Oral Presentation at the Peter Wall Centre, University of British Columbia. March 4th, 2004.

Smith, Neil. 1984. *Uneven Development: Nature, Capital and the Production of Space*. Basil Blackwell.

Smith, Neil. 1986. *Uneven Development and the Geography of Modernity. Social Concept*. Vol.4, pp.67-90.

Sontag, Susan. 1977. *On Photography*. New York: Farrar, Straus and Giroux.

Spitzer, Hartwig. 1977. Potential of the Open Skies Regime and Sensor Suite for Environmental Monitoring. Paper presented at the Third International Airborne Remote Sensing Conference and Exhibition, 7-10 July, 1977. Copenhagen, Denmark.

Staples, Gordon and J.Hornsby, W.Branson, K.O'Neill, P.Rolland. 2004. Turning the Scientifically Possible into the Operationally Practical: RADARSAT-2 Commercialization Plan. *Canadian Journal for Remote Sensing*, Vol.30 No.3 pp.408-414 (July 2004).

Stout, Mark and Thomas Quiggin. 1998. Exploiting the New High Resolution Satellite Imagery: Darwinian Imperatives? Commentary Series No.75, Canadian Security Intelligence Service Publication. Ottawa: Government of Canada.

Strong, Maurice. 2000. *Where On Earth Are We Going?* Toronto: Knopf.

Taylor, D.R.F. 1991. *Geographic Information Systems: The Microcomputer and Modern Cartography*. New York: Pergamon Press.

Trenholm, W.R., M.D. Thompson and I.K Crain.1995. "International Collaboration with respect to Global Monitoring: the Impact of Canadian Policy" in LeDrew, Ellsworth et al. (Eds). *The Canadian Remote Sensing Contribution to Understanding Global Change*. University of Waterloo Press Department of Geography Publication Series No.38, 1995, pp.353-373

United Nations. 1959. UN Resolution 1472. Available at:
www.oosa.unvienna.org/SpaceLaw/gares/html/gares_14_1472.html

United Nations. 1961. UN Resolution 1721. Available at:
www.oosa.unvienna.org/SpaceLaw/gares/html/gares_16_1721.html

United Nations. 1963. UN Resolution 1962. Available at:
www.oosa.unvienna.org/SpaceLaw/gares/html/gares_18_1962.html

United Nations. 1967. *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies*. United Nations General Assembly, New York: January 27, 1967

United Nations. 1986. *Principles Relating to Remote Sensing of the Earth from Outer Space*. United Nations General Assembly, New York: December 3, 1986

United Nations Development Program (UNDP). 2003. *Millenium Development Goals: A Compact Among Nations to End Human Poverty*. Human Development Report 2003. New York: United Nations Development Programme. (Overview)

United States (U.S.) Congress, Office of Technology Assessment. 1994. *Civilian Satellite Remote Sensing: A Strategic Approach*, OTA-ISS-607. Washington, DC: U.S. Government Printing Office.

- U.S. Congress. 1992. Land Remote Sensing Policy Act. Public Law 102-555.
- U.S. National Science and Technology Council. 1996. National Space Policy Fact Sheet. The White House, Washington, D.C. Available at: <http://www.ostp.gov/NSTC/html/fs/fs-5.html>
- U.S. Office of Technology Assessment. 1984. *Remote Sensing and the Private Sector: Issues for Discussion—A Technical Memorandum*. Washington, DC.: U.S. Congress, Office of Technology Assessment, OTA-TM-ISC-20, March (1984).
- U.S. Space Command (1997). *Vision for 2020*. US Space Command Director of Plans available at www.spacecom.af.mil/usspace
- Van der Sanden, J.J. and S.G. Ross (Eds.). 2001. Applications Potential of RADARSAT-2: A Preview. Ottawa: Natural Resources Canada, Canada Centre for Remote Sensing.
- Van der Sanden, J.J. 2004. Anticipated Applications Potential of RADARSAT-2 data. *Canadian Journal of Remote Sensing* Vol.30 No.3 pp 369-379 (July 2004).
- Wagner, Caroline S. 1998. International Agreements on Cooperation in Remote Sensing and Earth Observation. Washington, D.C.: Rand Corporation Publication.
- Weiss, Edith Brown. 1988. In fairness to future generations: International law, common patrimony, and intergenerational equity. UN University (Tokyo, Japan and Dobbs Ferry, N.Y.)
- White House (The). 2003. US Commercial Remote Sensing Policy. Available at www.whitehouse.gov/news/releases/2003/05/20030513-8.html
- Winnefeld, James A. and Mary E. Morris, eds. 1994. Where Environmental Concerns and Security Strategies Meet. Washington, D.C.: Rand Corporation Publication.
- Wirbel, Loring. 2002. The Space Industry: Supporting U.S. Supremacy. *Foreign Policy in Focus*. Vol. 7, No. 13 November 2002. Available at <http://www.fpiif.org/pdf/vol7/13ifspace.pdf>
- Wood, Denis. 1993. The Power of Maps. New York: Guilford Press

Citations Used to Summarize Evolution of Technical Literature on Earth Remote Sensing:

- Aird, W.J. 1977. Remote sensing: airborne mission planning. Ottawa: Environmental Impact Control Directorate.
- American Society of Photogrammetry. 1978. Digital Terrain Model (DTM) Symposium. St. Louis, Missouri, May 9 to 11 in *Photogrammetric engineering and remote sensing*. Falls Church, Va: Vol. 14, pp. 1477-1586.

Arst, K. Helgi. 2003. Optical properties and remote sensing of multicomponental water bodies. New York: Springer.

Bernstein, Ralph. (Ed.). 1978. Digital image processing for remote sensing. New York: IEEE Press, Wiley.

Bolle, Hans-Jürgen. (Ed.). 1979. Remote sounding of the atmosphere from space: proceedings of a symposium of the twenty-first plenary meeting of COSPAR, Innsbruck, Austria, 29 May to 10 June 1978. New York: Published for the Committee on Space Research by Pergamon Press.

Buttrick, Steven Colby. 1978. The alpine vegetation ecology and remote sensing of Teresa Island, British Columbia. Vancouver, B.C.: University of British Columbia.

Canadian Advisory Committee on Remote Sensing – Hydrology Working Group. 1976. Remote sensing of soil moisture and groundwater : workshop proceedings: Nov. 8-10, 1976, Royal York Hotel, Toronto, Ontario, Canada. Toronto: Canadian Aeronautics and Space Institute

European Space Agency. 1978. European Workshop on Space Oceanography, Navigation and Geodynamics: Schloss Elmau, Germany 16-21 January (1978). Paris: European Space Agency.

Giada, S., de Groeve, T., Ehrlich, D., Soille, P. 2003a. Can satellite images provide useful information on refugee camps? *International Journal of Remote Sensing*. 11/20/2003, Vol. 24 Issue 22, pp. 4249-4250. Available at <http://search.epnet.com/direct.asp?an=11426257&db=aph>

Giada, S., de Groeve, T., Ehrlich, D., Soille, P. (2003b). Information extraction from very high resolution satellite imagery over Lukole refugee camp, Tanzania. *International Journal of Remote Sensing*, 11/20/2003, Vol. 24 Issue 22, pp. 4251-4267. Available at <http://search.epnet.com/direct.asp?an=11426245&db=aph>

International Council of Scientific Unions. 1980. Passive radiometry of the ocean: proceedings of the sixth I.U.C.R.M. colloquium held at the Institute of Ocean Sciences, Patricia Bay near Victoria, B.C., Canada from June 14 to 21, 1978. Published in *Boundary-layer meteorology*. v. 18 (1980), pp. 1-358.

Jolly, Richard et al., (Jan J. Nossin, Ed.) 1976. Surveys for development : a multidisciplinary Approach. International Institute for Aerial Survey and Earth Sciences. New York : Elsevier Scientific Publications.

Krumpe, Paul F. 1976. The world remote sensing bibliographic index: a comprehensive geographic index bibliography to remote sensing site investigations of natural and agricultural resources throughout the world. Fairfax, Va: Tensor Industries.

Lenczowski R. 1997. "The military as users and producers of global spatial data." pp.85-110 in Rhind D. (Ed.), Framework for the World. Cambridge: GeoInformation International

Lintz, Joseph, and David S. Simonett. (Eds.). 1976. Remote sensing of environment. Reading, Mass: Addison-Wesley Pub. Co.

Lund, Terje (Ed.). 1978. Surveillance of environmental pollution and resources by electromagnetic waves : proceedings of the NATO Advanced Study Institute held in Spêatind, Norway, 9-19 April 1978. Boston: D. Reidel Pub. Co.

Moore, H. J. 1980. Lunar remote sensing and measurements. Washington: U.S. Govt. Print. Office.

Otterman, J. and E.A. Godby. (Eds.). 1978. The Contribution of space observations to global food information systems: proceedings of the W. Nordberg memorial symposium of the twentieth plenary meeting of COSPAR, Tel Aviv, Israel, 7-18 June (1977). New York: Published for the Committee on Space Research by Pergamon Press.

Parks, Lisa. 2001. Satellite Views of Srebrenica: Tele-Visuality and the Politics of Witnessing. *Social Identities*, (2001), v.7, no.4, Dec. pp.585-611. UK: K. Hyatt Stewart.

Smith, William L. (Ed.). 1977. Remote-sensing applications for mineral exploration. Stroudsburg, Pa.: Dowden, Hutchinson & Ross

Thompson, M. D., M. E. Kirby and M. C. Wride. 1978. Ecological habitat mapping of the Alberta Oil Sands Environmental Research Program study area. Edmonton: Alberta Oil Sands Research Program.

Verstappen, H. T. 1977. Remote sensing in geomorphology. New York : Elsevier Scientific Publications.

White, L. P. 1977. Aerial photography and remote sensing for soil survey. New York: Clarendon Press, 1977.

Zuev, Vladimir E. and Alain L. Fymat, (Eds.). 1978. Remote sensing of the atmosphere: inversion methods and applications. New York: Elsevier Scientific Publications.