A POLITICAL HISTORY OF U.S. COMMERCIAL REMOTE SENSING, 1984-2007: CONFLICT, COLLABORATION, AND THE ROLE OF KNOWLEDGE IN THE HIGH-TECH WORLD OF EARTH OBSERVATION SATELLITES

Kenneth P. Thompson

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Janet Abbate, Chair
Daryl Chubin
Anne Fitzpatrick
Timothy Luke
Gerald Toal

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A Political History of U.S. Commercial Remote Sensing, 1984-2007: Conflict, Collaboration, and the Role of Knowledge in the High-Tech World of Earth Observation Satellites

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Abstract

The political history of U.S. commercial remote sensing began in 1984 when the U.S. government first attempted to commercialize its civil earth observation satellite system – Landsat. Since then, the high technology of earth imaging satellite systems has generated intense debates and policy conflicts, primarily centered on U.S. government concerns over the national security and foreign policy implications of high-resolution commercial satellite systems. Conversely, proponents of commercial observation satellites have urged U.S. policymakers to recognize the scientific and socio-economic utility of commercial remote sensing and thus craft and implement regulatory regimes that allow for a greater degree of information openness and transparency in using earth observation satellite imagery. This dissertation traces and analyzes that tumultuous political history and examines the policy issues and social construction of commercial remote sensing to determine the role of knowledge in the effective crafting and execution of commercial remote sensing laws and policies.

Although individual and organizational perspectives, interests, missions, and cultures play a significant role in the social construction of commercial observation satellite systems and programs, the problem of insufficient knowledge of the myriad dimensions and complex nature of commercial remote sensing is a little studied but important component of this social construction process. Knowledge gaps concerning commercial remote sensing extend to various dimensions of the subject matter, such as the global, economic, technical, and legal/policy aspects.

Numerous examples of knowledge voids are examined to suggest a connection between deficient knowledge and divergent policy perceptions as they relate to commercial remote sensing. Relevant knowledge voids are then structurally categorized to demonstrate the vastness and complexity of commercial remote sensing policy issues and to offer recommendations on how to fill such knowledge gaps to effect increased collaboration between the US government and the U.S. commercial remote sensing industry. Finally, the dissertation offers suggestions for future STS studies on policy issues, particularly those that focus on the global dimensions of commercial remote sensing or on applying the knowledge gap concept advanced by this dissertation to other areas of science and technology policymaking.

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Dedication

This work is dedicated to Corinne Thompson, my spouse and helpmate, who has steadfastly supported and encouraged this effort through years of trials and tribulations and has encouraged me every step of the way.

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Chapter 1

Political Landscape of U.S. Commercial Remote Sensing

Overview of Commercial Remote Sensing Technology

Relevant as it is to the human condition, the global environment, and the global economy, remote sensing is, and will be, one of the most important technologies of the twentieth and twenty-first centuries.

– Joanne Gabrynowicz, 1993[1]

Imagine if we could extend our vision to allow us to view major sections of the surface of our planet from a perspective some hundreds of miles above the earth. Such a technical achievement, in the form of earth-orbiting satellite imaging systems, was made almost half a century ago. Perched atop powerful launch and booster rockets, extremely complex and expensive hardware, including high-tech imaging sensors, fuel and thruster systems, solar energy panels, and high-speed digital communications devices, are shot into position to orbit the Earth at around seventeen thousand miles per hour or about five miles per second. Once in orbit and operational, these prosthetic eyes begin scanning our land and sea surfaces and atmosphere and communicate imagery data to ground stations around the world.

Enabling the globalization of earth observation information, commercial remote sensing (CRS) satellite systems have provided an unprecedented wealth of information about the physical aspects and human utilization of our planet. Yet, while the scientific and socio-economic promises of this technology are great, remote sensing (particularly CRS) has created significant political conflicts and debates on how to optimize the benefits of this panoptic technology while guarding against the potential threats it can pose. To instill a sense of fascination for space remote sensing, it is useful to quickly trace the evolution of this politically charged technology.

Humans have always had an innate curiosity about the world in which it lives. To view, explore, and often conquer or exploit parts of the world, humans have ventured to other lands and continents in past centuries. While various motivations prompted such adventures, satisfaction of human curiosity aided by our visual sense was probably a significant factor. With the advent of balloons and later airplanes, humans were able to gain a new visual perspective of the earth and by the early 20th century, aerial photography and reconnaissance became a reality. Although a U.S.-launched V-2 rocket took photos of the earth in 1947, humans were only first able to view large expanses of our planet from spacebased artificial satellites in the late 1950s and early 1960s. In August 1959, the National Aeronautics and Space Administration's (NASA) satellite, Explorer-6, transmitted the first scanned photographs of the earth.[2] Shortly thereafter, NASA's weather observation satellite, Television and Infrared Observation Satellite (TIROS-1), provided images of earth and cloud masses on April 1, 1960.[3] Reportedly TIROS-1 transmitted 22,952 photos of the earth's cloud cover during a 77-day period.[4] In August of the same year (1960), hard-copy photographs of parts of the earth's surface were available (albeit, to a small segment of the U.S. Government [USG]) from the Discoverer/CORONA satellite. Later in the decade, excitement about viewing the earth reached a new level when the first total view of our planet was made possible during NASA's Apollo program.

Civil earth observation satellite programs continued to be the exclusive domain of the USG. until 1984, when the U.S. first attempted to commercialize its "Landsat" earth observation satellite system. Since then, the USG has attempted to foster a viable commercial earth observation industry. Yet, contentious policy issues and relationships between USG agencies and between the USG and the CRS industry have often hampered such efforts. This dissertation focuses on and provides insights into the politics of CRS and how the technology of earth observation satellites has influenced U.S. CRS legislation, policies, and regulations as a study in the interdisciplinary field of Science and Technology Studies (STS).

To make sense of the contentious issues surrounding CRS for USG officials and policymakers, it is useful to view CRS in all of its myriad dimensions. To comprehend the political and policy dynamics of CRS, it is helpful to view remote sensing as a large integrated system that extends beyond just the technical aspects of the satellites themselves. One can almost visualize remote sensing as a giant organism that requires various parts to efficiently function at an optimum level. Similar to the concept of network theory and large technological systems, such as electrical power generation and distribution systems (as advanced by Thomas Hughes),[5] CRS can be viewed as a super system that comprises hardware (satellites, sensors, ground stations, launch vehicles, communications and control systems); software (imagery processing, distribution, and analysis programs); data (images and value-added products), people (system operators, policymakers, regulators, scientists, national security personnel, civil/commercial data users); control and/or support mechanisms (CRS laws, policies, regulations, government contracts); and its supporting or competing environments (market conditions, insurance. foreign satellite systems, etc.).

Simply put, CRS is a vast arena of numerous players and artifacts. Each of these components interacts with and influences each other and often cannot function without each individual component. For example, one technical component (satellites) needs another socio-technical component (launch vehicles and personnel) to enter space and the latter component needs the regulatory component (launch licenses from the FAA) to actually get into space. That same technical component of CRS also requires the human element (private investors and/or government funders) to exist in the first place. Beyond the technical component (CRS systems), the human component (e.g., scientific researchers) requires data produced by remote sensing systems to pursue specific tasks (scientific research) and the relationship between these two components (researchers and data) has been supported by the legal/financial component of CRS in the form of government purchases of CRS imagery for various research projects. Further, since the system of U.S. CRS operates within a global economic and political environment of competing foreign systems, all of these factors (technical, social, data/information, financial) come into play and need to be understood to develop a comprehensive "thinking" of CRS and craft effective U.S. CRS policy and regulatory regimes.

Drawing on another STS concept (e.g. actor-network theory or ANT), a "remote sensing thinking" can invoke a concept of a power relationship between humans and artifacts. According to many ANT theorists (particularly Bruno Latour), artifacts/objects, textual devices, and humans are treated similarly in their power relationships.[6] Similarly, one can "think" of the politics of CRS as embodying parallel power relationships. CRS satellite sensor capabilities dictate the shape (content) of CRS regulatory regimes and influence policy perspectives (i.e., engender national security concerns or views that CRS can be used to reduce international tensions). Simultaneously, without various U.S. CRS laws and policies (the communications or textual component in ANT terms), the artifacts (CRS satellites) could not exist and operate in space.

Another STS scholar, Donald MacKenzie, offered a different type of "thinking" in understanding a large and complex technological system (nuclear missile guidance), which he called "nuclear thinking."[7] To MacKenzie, "nuclear thinking" meant how nuclear missile guidance systems were designed, developed, and employed (planned to be used) based on the inputs from a wide range of actors (engineers, military officials, bureaucrats, policymakers, etc.). Such thinking also extended to the destructive capabilities of nuclear missiles and warheads: those aimed at pinpoint destruction of enemy missile silos (the so-called counterforce strategy) and those aimed at destroying large urban areas in enemy territory (the so-called counter-value strategy).[8] Extrapolating from MacKenzie's theory of "nuclear thinking," this study conceptualizes what could be called "remote sensing thinking." In terms of U.S. CRS, such thinking can be characterized as viewing remote sensing systems (hardware, software, data, people) as being both useful to military operations and intelligence and posing military and national security threats if such systems were not strictly controlled and regulated by the government.

Conversely, "remote sensing thinking" can involve a perspective that such system components (hardware, software, data, people, etc.) can be used to benefit science, society, and the national security and foreign policy of the U.S. In examining these intricate social-artifactual-textual relationships throughout this dissertation, it is important to grasp another concept of "remote sensing thinking" that involves perspectives on what CRS would be like or how it could be used should there be no regulatory mechanisms to control the dual-use technology of earth observation satellites. Could there be a condition of remote sensing "anarchy," with bad actors causing substantial harm to humanity by using CRS imagery for destructive or exploitive purposes? Proponents for strict controls over U.S. CRS argue that the technology is easy to acquire and use and that the consequences for U.S. national security and foreign policy interests would be dire if U.S. CRS imaging activities were completely unregulated. Should unfettered conditions be the norm, one could envision a situation where a rogue nation such as Iran obtained very high-resolution imagery (perhaps from a U.S. satellite called GeoEye) of a sensitive U.S. military base in Qatar. The thinking then goes: With such imagery, the rogue nation would then be able to detect key military command and staff buildings and subsequently target them (and their occupants) with highly-lethal, missile-delivered chemical munitions.

Another form of "remote sensing thinking" akin to "anarchy" of CRS imagery data might entail the belief that super-high resolution U.S. imagery (perhaps .2 meters ground resolution imagery that would inevitably enter the open market absent regulatory regimes) could be used for economic espionage purposes. Imagine a scenario where competing industrial firms spied on each other using satellite imagery to figure out every aspect of their industrial processes or their practices in disposing of hazardous materials. Scenarios painted in this picture of unconstrained remote sensing are discussed in Appendix J (Information Barriers). The bottom line in this synoptic overview is that CRS entails more than just sensors and data and that a "remote sensing thinking" or perspective can help STS scholars and CRS policymakers grasp the magnitude and multidimensionality of the field of U.S. CRS and prevents one from focusing too heavily on the technical aspects of this very valuable but highly controversial technology

Significance of Commercial Remote Sensing and Its Political Ramifications

The ability to observe, monitor, and study the earth's surface and environment (land, sea, and atmosphere) has truly become a panoptic and global phenomenon. According to science historian and philosopher of sociobiology, Donna Haraway, the modern technology of earth imaging satellites is a "visualizing technology" that provides almost unlimited enhancement of human vision and the capability of "seeing everything from nowhere."[9] The standpoint of "nowhere" is, in her view, a privileged position. But CRS has another non-metaphorical but equally political standpoint: it is a view from somewhere, and that somewhere is space. Aside from its scientific, military, and economic utility, being able to view the earth from space also has important political ramifications. Since the 1960s, space has become the new high ground from which to view many areas of the earth without transcending international boundaries. In part, this has led to the politicization of space and has given rise to international treaties and resolutions on earth observation, such as the 1967 Outer Space Treaty and the 1986 U.N Principles Relating to Remote Sensing of the Earth from Outer Space, including the Moon and Other Celestial Bodies. The unique role that U.S. CRS has played and continues to play in the politicization of space is discussed throughout this dissertation.

Remote sensing technology has dramatically increased the human capability of vision and our ability to view the world in a detailed, comprehensive, and synoptic manner. Professor Mark Elam of Kobenhavns University adeptly characterized the technology of earth observation as enhancing our human capacities to view the earth and its inhabitants in a totally new light. According to Elam, "Space-based remote sensing offers us the advantage of prosthetic vision and the chance to use radiant energy from the hidden regions of the electromagnet spectrum to revolutionize our understanding of the shifting realities of life and the existence of planet Earth."[10] In addition to its awesome characteristics, remote sensing is a fascinating and powerful technology that provides a significant range of beneficial services for humanity – from increasing global political transparency, to advancing the science of understanding the earth and its environment, to numerous other civil, military, and commercial applications. For example, imagery from France's Satellite Pour l'Observation de la Terre (SPOT) was used during the diplomatic negotiations leading to the 1995 Dayton Peace Accord.[11] Similar applications for resolving current and future conflicts over highly contested territories involved using Indian IRS-1C and U.S. Ikonos satellite imagery to study the feasibility of using CRS imagery to monitor human activity and mitigate potential conflicts in the Spratly Islands in the South China Sea.[12] CRS imagery, such as that provided by the Indian IRS-1C, Russian KVR-1000, French SPOT, and U.S. Ikonos systems, have been used for international humanitarian relief efforts in places such as Thailand, Mexico, Africa, and even Europe (e.g., Kosovo, Macedonia, and Albania) to monitor and mitigate the plight of refugees.[13]

Other socio-economic benefits of using CRS imagery are extensive. CRS imagery can supplement or enhance civil remote sensing imagery in monitoring and mitigating natural disasters or hazards such as earthquakes, floods, and droughts. CRS imagery was effectively used during post-Katrina disaster relief efforts in the New Orleans area, providing near-real-time color imagery maps of the disaster area to relief personnel.[14]

Examples of commercial utility of CRS imagery are numerous. One such example is the use of DigitalGlobe's QuickBird imagery by the University of North Dakota to study crop diseases on sugar beet farms.[15] In another case, CRS imagery was highly useful for the telecommunications industry. Specifically, QuickBird imagery was used to create so-called digital city models (DCMs) of Washington, DC and Abu Dhabi, UAE. According to Rajesh Paul, Siva Subramanian, and Shalabh Bharadwaj of the Indian GIS firm RMSI, who reported on this novel use of CRS:

> Industries such as wireless telecommunications need to know the line of sight between their network antennae prior to network installation. The detail provided by this method enables operators to install antennae on buildings with a clear line of sight, thus optimizing network coverage and transmission quality. … Low to medium civil remote sensing imagery is simply too coarse to perform this function and aerial photographs are said to be more costly.[16]

Remote sensing has been called one of the most significant technological achievements of the 20th century.[17] Unfortunately, CRS technology has given rise to contentious issues over its regulation and control by the USG. Nevertheless, USG policies have spawned a small but growing CRS industry and related domestic and international market for geo-imagery. Concurrently, with the recent entry of CRS firms into the previously military domain of satellite reconnaissance, the U.S. is currently faced with significant policy issues and challenges.

Research Motivations and Strategy

The incredible technological achievements in designing and deploying prosthetic eyes in space to synoptically observe the earth's physical characteristics and the impact of human activity on the earth's environment prompted an interest in this study. Given the significance of U.S. CRS and its profound impact on the political, economic, social, and scientific sectors of society, and vice-versa, it seemed important to research the complex topic of the politics of CRS and subsequently provide policy insights and recommendations useful to CRS policymakers, the CRS industry, and others interested in this fascinating area of high technology. For several years now, interest in this topic led me to question whether the current policy regimes that govern CRS activities are as efficacious as possible and whether they mutually benefit all stakeholders, from commercial satellite operators to government agencies and programs, and ultimately to the general public and society.

A key focus of this research was on how the powerful technology of CRS affects the U.S. laws, policies, and regulations aimed at controlling its utilization through the political and bureaucratic process. Although numerous places on the earth can also be imaged by aerial photography, it was truly amazing to learn how earth imaging from space has created a much more contentious political/policy environment in the U.S. for the control and regulation of commercial imaging systems. What is it about these high-tech earth-orbiting machines that creates such intense debates, concerns, and conflicts over how to simultaneously promote and control them? How are laws, policies, and regulations crafted to achieve these seemingly dichotomous goals? Who are the actors involved in creating and implementing CRS control regimes? If CRS policies have been less than effective in meeting these goals, is lack of deep understanding about the complexities of the technology and its political and economic dimensions at the root of clashing policy perspectives on U.S. CRS activities? Seeking answers to such questions are important if one is to analyze and assess CRS policies and regulatory regimes and propose effective means of promoting the CRS industry in a manner that benefits CRS stakeholders and society as a whole.

Based entirely on open-source, unclassified research, this study traces the political history of U.S. CRS; the political, economic, and social dynamics of remote sensing technology; and the policy perspective of key stakeholders in the CRS arena (government, industry, and proponents and users of CRS imagery). Instead of focusing heavily on the technological aspects of CRS or even on how the technical capabilities of CRS have evolved or progressed in the past two decades (others have done that very ably), this study looks through the prism of STS to understand and analyze the political and policy issues created by CRS from its inception in 1984 to the early years of the 21st century. In doing so, it seemed imperative to survey the political landscape of CRS and to offer new insights and suggestions on how to improve the relationships between the CRS industry and the USG in this increasingly important sector of geospatial information technology.

Analytical Framework

To produce a dissertation using STS frameworks and theories, I used an analytical model similar to that used by Donald MacKenzie in his book, *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance*. MacKenzie's theoretical model offers several parallels with what I will accomplish in this dissertation. Specifically, MacKenzie attempted to debunk the old school of technological determinism by analyzing how a high-tech system such as missile guidance was created, developed, and implemented based on the socio-political inputs of key actors.[18] Using MacKenzie's framework as a model, I show how politics affect the creation and utilization of space-based CRS systems and how such systems, in turn, affect CRS laws, policies, and regulations in the U.S.

Expanding on MacKenzie's framework, I argue that, in addition to interests and institutional cultures/imperatives, stakeholder perspectives on CRS issues have also been influenced by what I call "knowledge voids." Knowledge voids are gaps in awareness or comprehension of the technical functionality and/or political-economic ramifications of CRS systems and activities. Such gaps have already been noted by a leading scholar on remote sensing law and policy, Joanne Gabrynowicz, who stated that government officials (particularly mid-level administrators, legislators, and their staff) are unfamiliar with or misinformed about civil and commercial remote sensing,[19] and by industry representative, Chuck Herring of DigitalGlobe, who claimed that even journalists continually misunderstand the nature of CRS, viewing it as simply a tool for digital mapping, whereas it offers many other useful applications.[20]

Reflecting the approach taken by MacKenzie, my research focuses on the challenges and problems faced by the CRS industry and its government patrons/regulators, provides insights into the complex human and organizational relationships involved in CRS policymaking, and offers recommendations to U.S. policymakers and CRS regulatory agencies. This study of the political dynamics of CRS technology adds to the existing STS literature by detailing the influences of individual and organizational perspectives on CRS policies and regulations and by offering a new concept (i.e., CRS knowledge voids) that helps explain the social shaping of policy and thereby guides future policy efforts.

Situating Remote Sensing in Its Geopolitcal and Geoeconomic Contexts

To gain a sense of the power and influence of earth observation satellites on politics, economics, and ideology, it is helpful to view these fascinating remote sensors in their geopolitical and geoeconomic contexts. Earth observation satellites acquire information on a global scale, transcending the limits of borders and national sovereignty. These prosthetic eyes in space are able to penetrate denied areas with capabilities that exceeded their predecessor balloon and airbreathing cousins (aerial photography). In a geopolitical context, civil and commercial observation satellites were used as a political tool – peering into the inner confines of states involved in weapons proliferation, human rights abuses, border disputes, and other activities that were once thought protected by physical boundaries and geophysical space. However, with the advent of spaceborne remote sensors, terrestrial borders and vast physical spaces could not longer inhibit this transparency.

Prior to and following the commercialization of earth observations satellites (Landsat), geopolitics played a role in the global discourse on the panoptic system of earth-viewing satellites and challenged some of the basic tenets of traditional geopolitical theories. When it came to earth observation satellites, state borders no longer ensured state sovereignty since these earth-orbiting platforms extended the spatial dimension of geopolitics from land, sea, and air to that of space. This new perspective on geopolitics caused eight equatorial nations to argue that their territorial sovereignty extended from the ground all the way up to the geostationary orbits of weather satellites. Such view, as advocated the equatorial nations was expressed in the 1976 Bogotá Declaration, challenged some of the provisions of the Outer Space Treaty.[21] However, such geopolitical perspectives were rejected by the majority of other states that reaffirm the treaty as not recognizing the applicability of terrestrial sovereignty to the operations of earth-orbiting civil satellites.

Following the Cold War, new perspectives on geopolitics in the context of remote sensing and other space activities eventually gave rise to new geopolitical terms such as space politics and "astropoltics."[22] As the Cold War was reaching its final stage, para-commercial observation satellites such as the U.S. Landsat, French SPOT, Indian IRS, and Russian KVR and KFA systems were taking medium- to high-resolution photographs of most parts of the earth by transcending international borders. These high-tech space systems were imaging the natural resources and industrial, economic, and political-military activities once thought relatively immune to the peering eyes of foreign states. Although this new geopolitical dimension of international relations created conflicts and contentious political discourse among various nation-states, it also helped the U.S. in its quest to tip the balance in its favor in bipolar politics during the Cold War. In the case of Landsat, geoimagery was used to promote U.S. ideals of transparency and societal openness in contrast to the Soviet-block's views on a closed society. This was done through the deployment of several ground stations in various regions of the world and making Landsat data available on a non-discriminatory basis to all nations that operated those stations and to other nations to which the ground-station operators chose to sell Landsat imagery. According to Joanne Gabrynowicz, the Landsat system was originally used a geopolitical tool to demonstrate the superiority of U.S. technology in geoimaging and to promote the ideal of sharing information about the earth's surface and its environment and natural resources.[23]

Prior to the advent of CRS in the U.S., pre -1984 remote sensing (Landsat imaging) was driven in part by science and politics. In addition to demonstrating its scientific and technological capabilities vise-a-vise the Soviet Union – a form of geopolitical competition – the U.S. wanted other nations to have access to Landsat data to influence them from a foreign policy perspective. Yet, despite these Cold War ideals, civil and CRS satellites were perceived as potential threats to the once-held military monopoly over low-earth-orbit (LEO) geoimaging systems. In a reactive mode, the U.S. national security establishment placed restrictions on the privatized Landsat to possess no better imaging capabilities than 30 meters ground resolution. Still, Landsat allowed another set of eyes on the world to assist environmental and earth scientists as well as the military. Ironically, the commercialized Landsat actually helped the military (DOD was its largest customer for imagery data in the 1980s and early 1990s). Recounting the military utility of CRS satellites in a geopolitical context, both Landsat and SPOT imagery were used during the 1991 Gulf War to provide military maps and to monitor ecological disasters in the area (i.e., oil fires and oil spills due to the actions of Saddam Hussein).

Following the Cold War, use of remote sensing continued to be seen as beneficial in aiding and understanding and analysis of geopolitical conflicts. For example, U.S., Indian, French, and Canadian CRS imagery was used to ameliorate potential conflicts in world hot spots such as the Spratley Islands in the South China Sea, border disputes in Ecuador and Peru, and the conflict in the Balkans (Kosovo).[24] Moreover, following the Cold War, geopolitical thinking began to give way to new concepts and discourse that increased an understanding of how transnational economic competition became as important as geopolitical considerations. The new concept was called geo-economics and has been written about by scholars and thinkers such as Edward Luttwak and Gerald Toal.[25]

Although geopolitics is still valid and important in influencing international relations, geoeconomics or economic globalism serves as an insightful intellectual framework within which to view and comprehend the significant role that CRS has played and continues to play since the end of the Cold War. Specifically, CRS is gradually supplementing its defense and foreign policy utility with a rapidly evolving commercial utility. Remote sensing markets are complex and involve activities from earth observation data acquisition in space to value-added services provided by numerous small- and medium-scale enterprises. A primary goal of CRS satellite systems (operators) is to make a profit on a domestic and global scale. The customer reach for CRS imagery now spans the globe and there is fierce completion among CRS imagery providers in multiple countries. Commercial observation satellites are now seen as an economic means for satisfying the increasing global demand for geospatial information.

In the 1990s, U.S. policymakers wanted the U.S. to capture a dominant share of the world market for earth observation data. Unfortunately, that economic goal was hampered by another goal – foreign policy and national security concerns over nefarious uses of CRS imagery by actors or states inimical to the interests of the U.S. Conversely, strong advocates of relatively unfettered CRS claim that the emerging commercial observation satellite firms will contribute to the geo-economics of the 21st century by seeking a place in the broader geospatial information technology market (and as a result, a place in the even broader IT marketplace). Distribution of space imagery on platforms such as GoogleEarth will greatly promote the popularity of that information and will increase its economic value. In the geoeconomic era, other countries will inevitably come up with their own novel applications that continue this trend.

Even the geo-economic dimension of remote sensing (i.e., GoogleEarth) has impacted the geopolitical dimension. A prime example is the perceived intrusion of the spatial dimension of the Republic of Korea (ROK) by GoogleEarth imagery on the Internet. When ROK officials discovered the ROK President's residence (called the "Blue House") on GoogleEarth, they were exceeding alarmed and sent a delegation to the U.S. to voice their concerns to GoogleEarth. However, in this case, the power of economics trumped the geopolitical and security concerns of the ROK and GoogleEarth did not remove the Blue House from its imagery database.[26] This example and many others like it demonstrate how geopolitical considerations are still important in assessing the power of CRS and its impact on foreign policy issues and the creation of knowledge voids. In the case of the latter, a strong Israeli lobby pressured the U.S. Congress into passing an amendment to the 1997 Defense Authorization Act that prohibited imaging of the state of Israeli (for security and geopolitical purposes) by U.S. CRS satellites at ground-resolution capabilities exceeding that of other CRS systems in the world. Here, Post Cold War-era geopolitical and foreign policy concerns caused a blackout of knowledge of sensitive military sites and activities within the territory of Israeli that could have been provided by future CRS firms (at the time) such as Space Imaging and EarthWatch (now Digital Globe).

Increased availability of civil and commercial remote sensing data and information in the global marketplace will undoubtedly make it easier for NGOs and the media to pursue or debate economic and ideological issues, such as the gulf between rich and poor nations (i.e., economic asymmetry between the developed and developing world). For instance, environmental NGOs and other researchers have used civil and CRS imagery to point out the problems of deforestation in such areas as the Amazon River basin, an economic activity for loggers in Brazil that is being challenged by environmental groups and researchers.[27] CRS imagery is also helping to bolster the economic conditions of places like Europe where electro-optical and radar imagery is used to promote agriculture and to prevent agricultural fraud from the highly subsidized farming industry in that region.

CRS satellites and the imagery products and services that they produce could be seen as a more powerful tool for economic competition and cooperation than for its political and defense applications, but it may take a long time to reach that stage. Still, it seems to be moving in that direction. The increasing global marketshare captured by U.S. CRS activities has been reported by the American Society for Photogrammetry and Remote Sensing (ASPRS) as being on a continual upswing. According to ASPRS, gross revenues from the remote sensing industry (spaceborne and aerial) and related value-added serves is projected to reach over $6 billion by 2010.[28] Since satellite imagery sales constitutes about thirty percent of that figure, their take will be over $2 billion annually in the next three years.[29] The value of this brief geopolitical and geoeconomic overview of CRS in its political and historical context is that CRS is a powerful and highly influential technology that transcends international boundaries and claimed sovereignty over state territory. As a result, CRS can be viewed from a comprehensive analytical perspective to help promote the U.S. CRS industry and assess CRS policies that have that objective as their stated goal.

Nexus of Politics and Remote Sensing Technology

As a large technological system, the global panopticon of earth-imaging satellites has significant political implications that directly impact society. As earth observation systems have steadily advanced in technological sophistication, the U.S. political and bureaucratic institutions have been and will continue to be increasingly challenged to create, develop, refine, and implement policies that both promote the U.S. CRS industry and protect society (primarily in the U.S. but also on the international stage) from perceived threats posed by CRS systems. Such threats include the use of CRS as potential weapons in the hands of terrorists and narco-criminal enterprises, etc. The fact that CRS is considered a dual-use technology (i.e., can be used for military and non-military purposes) has created a rocky relationship between the U.S. CRS industry and USG actors. In other words, the technological capabilities of commercial observation satellites create a plethora of national security concerns and contentious policy issues.

MacKenzie identified a similar phenomenon in his study of missile guidance systems and the political and organizational environment in which such systems were developed and used. According to MacKenzie, "…as we enter the black box we find that the distinction between politics and technology becomes harder to make."[30] While the technological capabilities of CRS create contentious political issues due to its inherent dual-use nature, politics (i.e., policies and bureaucratic decisions) also affect the design and utilization of CRS systems. Even before U.S. CRS firms can begin to design and build CRS satellites, they need to obtain U.S. licenses that set or limit CRS imaging capabilities such as panchromatic and multispectral resolution. Once CRS systems have been built and launched, politics also come into play in determining how CRS systems can be operated and its imagery distributed (e.g., selective shutter control measures and imagery dissemination restrictions, commonly known as the "24-hour rule").

MacKenzie argued that participants on each side of the political/technology divide consider their individual realms or domains as distinctly separate from each other. This political-technological divide (often found in the high-tech world of remote sensing as well) was made particularly salient by MacKenzie as he noted: "It is a distinction central to how they [political, military, and technological stakeholders] talk and, as I am about to argue, a distinction central to their success or failure."[31] So does this perception also apply to past and present interventions between the developers and operators of civil and private remote sensing satellites and the bureaucrats and politicians whose job it is to control such systems?

Like many other STS scholars, MacKenzie sees a propensity of people on the technology side to view the political sphere as intruding on technology. Thomas Gieryn and Sheila Jasanoff also describe this tendency (i.e., scientists/technologists protecting their knowledge domains when it suits their interests) in their research on boundary work and scientific policymaking.[32] Others who write about the nexus of politics and technology have also advanced similar views. For example, borrowing a theme from Rob Kitchin (i.e., the utopian-dystopian dichotomy in the cyberspace arena)[33] and applying it to remote sensing, one can offer similar notions regarding the political consequences of the global panoptic age (i.e., utopian, or creation of an environment of global transparency in information and international politics vs. dystopian or creation of an environment for greater threats and instability). While addressing cyberspace issues, Kitchin argued, "It is imperative that individual citizens, academics and representatives of both government and industry activity engage in exploring these questions [concerning politics and policy] if we are to ensure the success of cyberspatial technology and reap the potential benefits they offer."[34]

Kitchin's approach to gaining a greater appreciation and understanding of information technology was to assess the socio-political changes occurring within that field. In doing so, he focused on the relationships between "individuals/institutions and technology, while acknowledging that these constructions are based within a historical context and the wider political agenda of nations and businesses."[35] Thus, extrapolating Kitchin's arguments and applying them to the not-so different enterprise of remote sensing, I became aware of the importance of comprehending and analyzing the organizational/institutional and political-economic dynamics of CRS and what I view as knowledge voids and perception gaps that exist among various communities of CRS stakeholders/proponents and political actors.

In addition to drawing on the analytical approaches and frameworks of the aforementioned scholars who have written on technology issues, this dissertation sheds new light on how knowledge (or lack thereof) of CRS policy issues creates conflicts during the various stages of CRS policymaking, from Congressional hearings to debates over U.S. CRS rules and regulations. In effect, this dissertation creates a new STS model that considers the role of knowledge (or lack thereof) and how it influences policy perceptions that determine the ultimate forms of U.S. CRS laws, policies, and regulations. This dissertation also focuses on the intricate interconnectedness of CRS policy issues in its national security, foreign policy, economic, technological and legal dimensions and posits how such complicated issues can actually contribute to knowledge voids on this topic.

Although the STS literature is replete with various theories that address the social construction of facts and knowledge (i.e., social worlds theory; conflict theory, lab studies, interest theories, actor-network theory, etc.), this dissertation takes a converse approach by examining and analyzing lack of knowledge and its potential causes and how such knowledge voids influence divergent perceptions on how to view, utilize, and control technology (e.g., remote sensing technology in this case). While it does not attempt to prove a cause-and-effect relationship between knowledge voids and perception gaps, it suggests a possible linkage between the two and attempts to stimulate thinking and discourse on the topic. This model (knowledge voids and perception gaps related to a dual-sue technology in its socio-political context) supplements the existing STS literature on how extant knowledge potentially effects perceptions or vice versa and thus it can be applied to other S&T policy issues examined by STS researchers.

Influence of U.S. CRS on Policymaking and Bureaucratic Organizations

Remote sensing is not simply a benign technology. As commercial observation satellites have evolved into highly advanced systems that nearly rival the capabilities of military reconnaissance satellites, a host of newly charged political issues have emerged. Consequently, CRS satellite operators and government policymakers need to be cognizant of the costs and benefits of CRS technology. As many would probably recognize, remote sensing provides a plethora of geo-imaged data useful in myriad ways, from tracking land use and monitoring the environment to updating increasingly obsolete maps. Yet, as has been proven so often with many other technologies (e.g., nuclear technology to digital communications and computers), remote-sensing capabilities can also present formidable problems for humanity, from potential invasion of privacy (i.e., tracking our every move or monitoring activity that some would want to keep hidden) to enabling hostile actions between governments and non-state actors alike. Two prominent experts on the politics of remote sensing, Ann Florini and Yahya Dehqanzada, see CRS as a tool for potentially harmful and aggressive acts. To them, "Governments, corporations, or small groups could use the imagery to conduct industrial espionage, collect intelligence, plan terrorist attacks, or mount offensive military operations."[36]

During research for this dissertation, additional questions came to mind such as: How should the U.S. effectively and beneficially craft and implement its national policies and strategy for regulating and controlling CRS activities? How can national security be balanced against the wellbeing and economic viability of the CRS industry? To what extent should the USG continue to fund or support CRS research and development and satellite operations in the face of mounting foreign competition in this technological arena? Finally, what can policymakers learn from the experiences and viewpoints of the CRS industry and what can the latter learn from understanding the policy processes of its government patrons and overseers? With these questions in mind, the primary objective of this dissertation was to survey and analyze the interplay between politics and technology in the realm of CRS and the perspectives of its stakeholders in both the private and public sector. My research eventually led me to offer proposals and recommendations (see Chapter 4) for more efficacious and flexible national policies aimed at promoting CRS activities and for filling pervasive knowledge voids concerning CRS policy issues. My thesis and argument is that greater understanding of the positions, interest, motivations, and values of these seemingly dichotomous sectors (i.e., industry and government), using the interdisciplinary tools of STS, will serve as a bridging mechanism and foster greater cooperation and collaboration among key CRS stakeholders to achieve mutually beneficial goals and objectives.

As this dissertation unfolds, I review current U.S. policies applicable to CRS technology and operations and describe, analyze, and critique perspectives on such policies by stakeholders such as the CRS industry, government policymakers, and CRS regulatory agencies. Questions probed were: Do we desire the status quo or bold new steps in U.S. CRS policy? If the latter, how should this be accomplished? As I argue throughout this dissertation, it is through deep knowledge and understanding of the perspectives, goals, and visions of all stakeholders in the CRS policy area that CRS can be a viable and growing industry.

To date, CRS is a niche market and a narrowly confined field of interest among USG agencies, academic institutions, and other sectors of society. The general public has not yet been a significant stakeholder in CRS policy issues, but that could change as the popularity of CRS applications such as Google Earth and Microsoft's Virtual Earth increases. Still, the CRS industry and the USG vicariously represent the interests of the general public. For example, the USG meets its obligation to protect the public by adhering to its national security perspectives. Of course, this has created a tension between strict and flexible CRS policy decisions. Conversely, industry represents those segments of the public that use CRS imagery such as forestry, agriculture, mining, public utilities, earth science, and many others endeavors for the commercial and public good. Unfortunately, these sectors comprise only a small percentage of U.S. CRS and this skews the political influence in the direction of the defense and security agencies for CRS policymaking. Most of the U.S. CRS firms' customers are the USG and foreign defense clients. Once CRS becomes truly commercialized and affects or enhances the lives of the average citizen (e.g., Google Earth or imagery-enhanced visualization for affordable navigation systems), industry should be able to leverage the power of the public to increasingly lobby its positions with the USG for advanced CRS capabilities and less restrictive CRS operations.

With these issues in mind, research for this dissertation focused on providing insights for developing new tools and frameworks for policymakers to accomplish their stated goals to bolster the U.S. CRS industry. In addition, this research project contributes to the academic knowledge base for CRS policymaking in the U.S. from an STS perspective. This academic endeavor entailed a comprehensive study of the socio-political dimensions of the institutions and key stakeholders involved in establishing, developing, and promoting a remote sensing industry in the U.S. from the mid-1980s to the present. While doing so, particular attention was paid to instances of knowledge gaps manifested by those who study and write about CRS and by those charged with crafting and implementing U.S. CRS policies and regulations.

Historical Background of U.S. Attempts to Promote Commercial Remote Sensing

The political history of the privatization or commercialization of U.S. satellite systems can be broken down into two general periods: the privatization period from 1984 to 1992 and the transitional period from 1992 to the present. The full commercialization period has yet to arrive. That period should occur once the CRS industry is able to stand on its own in marketing its products without substantial government subsidies or contracts. By most accounts, the privatization period ended up being a failure for U.S. policymakers. Fortunately, the transitional period looks much better, since the U.S. finally put practical laws and policies into place to foster a viable CRS industry. However, this latter period is not without its political/policy challenges and problems and has not yet led to the full commercialization of U.S. CRS satellite systems. Yet, the transitional period is one in which several U.S. CRS satellites were successfully launched and operated in space.

U.S. civil and commercial remote sensing systems were not the only technological systems that have had an effect on U.S. politics and policies for earth observation activities. Since 1986, other nations (in addition to the Former Soviet Union) have entered the arena of remote sensing, and today the earth is continually observed and imaged by dozens of civil or commercial imaging satellites. This increase in foreign earth observation systems has significantly impacted U.S. CRS policymaking. Yet, foreign civil/CRS satellite systems and programs have not been adequately appreciated or understood, largely due to knowledge gaps in this area. Describing and analyzing the privatization and transitional periods provides context and insights into how politics have played a crucial role in the successes and failures of U.S. efforts to promote a viable and self-sufficient private or commercial earth observation industry. As the full commercialization period has yet to arrive, an ancillary objective of this study is to provide insights into the relationship between policymaking and bureaucratic decisions/actions and the technology of CRS and to formulate strategies for eventually bringing about such a period or era.

Privatization Period (1984-1992)

To appreciate the tumultuous history of U.S. attempts to commercialize its civil earth observation systems, one needs to hark back to the early days of the Landsat system, the U.S.'s first civil earth observation system, and the policies and legislation that it spawned. First called the Earth Resources Technology Satellite, Landsat was built and subsequently launched by NASA in 1972 as an experimental earth observation satellite to test onboard imaging sensors. As organizations such as the Department of the Interior (DOI), other USG entities, and scientific researches found its imagery to be useful, Landsat became more of an operational vs. an experimental system. By the early 1980s, the U.S. began working on a program to commercialize the civil Landsat satellite system, which resulted in the passage of the Land Remote Sensing Commercialization Act of 1984. Given the licensing authority provided by the 1984 Commercialization Act, DOC issued requests for proposal (RFPs) to solicit bids on a contract to commercially operate the Landsat systems and the Earth Observation Satellite Corporation (EOSAT) won a USG contract in August 1984 to operate Landsat, market its imagery products, and develop the future Landsat-6 and -7 series of satellite systems.

For the next eight turbulent years, the Landsat program became a political football and a grand experiment to privatize the Landsat satellites. Those efforts ultimately failed and led to the USG diverting the Landsat system back to government control and passing the Land Remote Sensing Policy Act of 1992. Still, it took another seven years before the first high-resolution U.S. CRS satellite (i.e., Space Imaging's Ikonos-2) was successfully placed into orbit in 1999 to begin observing the surface of our planet. Although Orbimage (a CRS company) placed its Orbview-1 and Orbview-2 satellites into orbit in 1995 and 1997, respectively, those systems were primarily in support of NASA's atmospheric and ocean monitoring programs, and thus were akin to civil observation satellites.[37]

According to Joanne Gabrynowicz, initial attempts to commercialize the civil Landsat system were plagued by the divergent opinions and policy perspectives of USG officials and policymakers and the commercial sector (represented by the Landsat operator, EOSAT.[38] Conflict over these issues between the legislative and executive branches were incessant. Many people involved in policymaking and federal budgetary matters did not seem to understand or perhaps ignored the economic impact of USG decisions on the company (EOSAT) that won the bid to take over the Landsat program. One such conflict centered on divergent perceptions as to the role of Landsat. Did its imagery data serve government needs such as mapmaking for DOD or did it serve commercial needs such as geological surveys that benefited the extraction industries? If the latter, then the USG was more inclined to think that the Landsat should be commercialized and that government support for the system should be reduced over time. Another point of conflict was NOAA's lack of full support of the commercialization program by not requesting funds from Congress during several fiscal years in the late 198's because NOAA felt it had no obligation to do so past the expected lives of the Landsat-4 and -5 satellites, whereas those satellites lasted longer than anticipated. These actions antagonized certain members of Congress. According Ray Williamson citing a 1991 Congressional Research Service Report, disagreements between EOSTA, the administration, and Congress concerning continued Landsat funding delayed a decision to fund the Landsat system until the spring of 1987."[39] The administration (particularly OMB, EOSTA, and Congress even wrangled over whether to build both Landsat-6 and -7 or just Landsat-6. Money was generally the root issue in these conflicts. Another problem with this commercialization fiasco is because NOAA really didn't want the Landsat management responsibility and was more interested in its weather satellites than in a land imaging system.

Although the actual privatization period began in 1984 with the passage of the Land Remote Sensing Commercialization Act, the USG began envisioning the privatization or commercialization of the Landsat system in the late 1970s, some five years after the first Landsat satellite was placed into orbit in 1972. According to the now declassified Presidential Directive-54 (PD-54), which is often incorrectly known as "Presidential Decision Directive-54," the USG's goal was "the eventual operation of the private sector of our civil land remote sensing activities."[40] Under PD-54, DOC was tasked to study how the private sector could participate in the Landsat program.[41]

In the early 1980s, the USG began shifting its policy focus from operating the Landsat system as a government-operated civil remote sensing system to a fully privatized/commercialized system. At the time, NASA had already launched its fourth Landsat satellite and, by 1983, the National Oceanic and Atmospheric Administration (NOAA) had taken over operational control of the Landsat satellites.[42] According to Ray Williamson of the Space Policy Institute of The George Washington University, the Reagan administration pushed ahead with its commercialization efforts despite three studies commissioned by NOAA that indicated the CRS market was immature and not ready to profitably support such actions.[43] Although the studies had a cautionary tone, the Reagan administration's overriding interest was in moving the civil Landsat program to the private sector because it felt that the private sector could run the program more efficiently and make it profitable. Perhaps this was a knowledge gap in both the legislative and executive branches of the USG. According to a NASA chronology of the Landsat program, the 1983 studies indicated there were no viable options for commercializing Landsat in the near term or even in the long run without significant financial support from the USG.[44] Ignoring or unaware of such advice, proposals were submitted to Congress to press ahead with its commercialization plans.[45]

Congress began holding hearings in 1983 and 1984 with the intent to craft legislation for the commercialization of the civil Landsat program. At the time called "privatization" by many persons, these efforts ultimately led to the passage of the Land Remote Sensing

Commercialization Act (aka "Landsat Act" or what I call the "Commercialization Act") on July 17, 1984. The stated purpose of the Act (in Title III) was "to provide, in an orderly manner and with minimal risk, for a transition from Government operation to private, commercial operation of civil land remote-sensing systems;…"[46] Key provisions of the 1984 Act granted responsibility to DOC to contract with a private firm to assume operations of the Landsat system and made it clear that the USG still owned the satellites, but a private contractor could lease the systems and market its data.[47] Most notably, the Act gave DOC the authority to license private remote sensing space systems but only if licensees comply with the requirements of the Act "and any applicable international obligations and national security concerns of the United States."[48] Much of the language of the licensing provisions of the 1984 Act later migrated to the Land Remote Sensing Policy Act of 1992, PDD-23, and various iterations of NOAA's regulations for the CRS industry. Often, many CRS watchers do not have a complete historical perspective concerning the basis for CRS licensing authority, which prevents them from realizing that the licensing authority was already in place in 1984 and that the primary constraint to successful U.S. CRS ventures in the 1980s and early 1990s was lack of a viable commercial market for CRS imagery, not the nonexistence of such licensing authority prior to 1992. As is readily discernable, the only differences in the language in the two Acts for the licensing aspect are essentially the bolded terms below:

> [1984 Act, Title IV, Section 410 (a) (1)] In consultation with other appropriate **Federal** agencies, the Secretary is authorized to license private sector parties to operate private remote-sensing space systems for such periods as the Secretary many specify and in accordance with the provisions of this title.[49]
>
> [1992 Act, Subchapter II, Section 5621, (a) (1)] In consultation with other appropriate **United States Government** agencies, the Secretary is authorized to license private sector parties to operate private remote sensing space systems for such period as the Secretary may specify and in accordance with the provisions of this title.[50]

Yet, numerous individuals who study and report on CRS policy issues and legal regimes fail to note that it was the 1984 Act, not necessarily the 1992 Act, that gave DOC the authority to grant CRS licenses,[51] and instead, have a tendency to credit the 1992 Act as the legal vehicle that, according to CRS scholars Kevin O'Connell and Gregory Hilgenberg, "opened the door to licensing of US commercial remote sensing satellites."[52] In fact, that door was created back in 1984. One of the reasons why CRS firms (except for EOSAT) did not step through that door is because there was no viable market (except for the USG) for CRS imagery sales in the 1980s. Another reason is that, during the 1980s, the information technology infrastructure (in the form of geographic information systems or GIS) was not available to support a wider user base for CRS imagery analysis and utilization.[53]

In defense of knowledge voids concerning the 1984 law, one could argue from a legalistic perspective that the 1992 law repealed the 1984 law and, thus, the latter legislation served as the operative basis for post-1992 CRS licensing actions. Yet, such a perspective misses the point that, although the 1984 law provided opportunities for the U.S. space industry to enter the CRS business in the 1980s, the market and IT infrastructure were not conducive for such enterprises during that period. Since a plethora of CRS license applications were submitted shortly after the

1992 Policy Act,[54] it is also understandable that people would perceive it to be the initial legal authority and starting gate for CRS licensing. Often, it is a law's implementation and results rather than its language that establishes its relative importance and shapes perspectives about it, particularly in a historical context. For this reason, it is important to have a good grasp of the historical facts surrounding CRS policymaking and the context in which CRS legislation is crafted, particularly the fact that it was the 1984 and 1992 Acts (not PDD-23) that were the impetus for CRS ventures in the U.S.[55] It is also important to understand the pre-1992 period of U.S. attempts to commercialize land remote sensing satellites when attempting to gain insights into the political history of U.S. CRS activities.

Shortly after the passage of the 1984 Commercialization Act, EOSAT, a partnership between RCA and Hughes Aircraft (based in Lanham, Maryland), began operating Landsat-4 and -5 by October 1985. Yet, throughout the remainder of the 1980s, EOSAT and the USG found it difficult to cooperate with each other to find suitable funding programs capable of supporting Landsat operations and developing follow-on systems. According to Williamson, "…Congress, the administration, and EOSAT made several abortive attempts to find a funding plan to develop Landsat-6 and -7 that was acceptable to all parties."[56]

Congress and the administration evidently misunderstood or at least ignored the economic reality of operating the Landsat system as a commercial venture. Legislation mandating the sale of Landsat imagery on a non-discriminatory basis was a problem for EOSAT because it could not offer discounts to volume purchasers (of imagery) – a common business practice in other industries. Lingering doubts about or resistance to funding the Landsat program, primarily by the Office of Management and Budget (OMB) was also a problem.[57] OMB staffers felt that EOSATS's imagery sales should rapidly progress to a point where the company would become self-supporting and no longer need government funding. The problem with that view is that the markets for a truly self-supporting CRS industry was not predicted to emerge until the late 1990s, and even today U.S. CRS firms still need imagery-purchasing contracts with the USG to survive.

One of the scholars who has written extensively about the era of Landsat privatization and its policy failures is Donald Lauer, former President of the American Society for Photogrammetry and Remote Sensing (ASPRS). Writing about 1980-era U.S. remote sensing policy issues, Lauer stated that "funding to operate Landsat 4 and 5 remained precarious."[58] Lauer further opined, "As a result of uncertain, unpredictable, and vacillating government policies, the status of the nation's Landsat program is [was] in jeopardy (i.e., no assurance that Landsat 4 and 5 will be maintained and operated beyond 1990 if functionally still intact, …."[59]

Throughout his lengthy dissertation on this subject, Lauer argued that policy complexities and uncooperative relationships between key stakeholders of the Landsat system plagued the USG's attempt to privatize/commercialize Landsat. Key among these problems was the Reagan administration's ignorance of the prospects for commercial viability of the Landsat system in the 1980s and beyond, without massive financial subsidies from the USG. Most likely, the USG organization most knowledgeable about the prospects for a successful (or doomed) privatization/commercialization of the Landsat system was DOC. On several occasions DOC (through NOAA) warned the Reagan administration that the Landsat system was not ready for commercialization.[60] According to Lauer, "two of the three [DOC] contract studies provided complete financial analyses of system lifetime scenarios and concluded that projected revenues could not support an independent private sector system until well into the 21st century."[61]

Apparently, poor estimates of its commercial viability in the 1980s, and other factors such as ideological perceptions contributed to the policy fiasco. Bureaucratic infighting between various institutions such as DOC and DOI (which advocated continued government funding in the near- to mid-term) and OMB and the Reagan administration (which were interested in reducing the federal budget) also accounted for policy and programmatic conflicts. Congress was caught in the middle of this fray. NOAA, the largest component of DOC, was directed by that Department to manage the EOSAT contract for operation of the then current Landsat systems and development of follow-on systems (Landsat-6 and -7). Yet, NOAA, and DOC for that matter, were small and relatively weak organizations compared to powerful and highly visible offices such as OMB and the White House and did not have the political clout of the latter organizations. Often Landsat funding issues had to be elevated to the President and his staff to seek resolution and prevent the demise of the Landsat program.[62]

The already shaky viability of the privatized Landsat system was dealt a significant blow by technological developments outside the U.S. While the USG and EOSAT were wrangling over funding issues involving the development of Landsat-6 and -7 during a period that many later characterized as a failed attempt at commercializing the Landsat program, other nations such as France, India, and Russia were about to compete against Landsat imagery sales. As far back as the early 1970s, France began planning on a medium-resolution earth observation system and in 1986 it launched its first government-funded CRS satellite, SPOT, with a resolution of 10 meters (greatly exceeding the capabilities of the 30-meter Landsat system, the only other civil remote sensing satellite at that time). Similar to the Sputnik shock of 1957, this foreign technological achievement caught the attention of USG policymakers.

Later, as if to send additional shocks to U.S policymakers and CRS supporters, India launched its first earth observation satellite, India Remote Sensing (IRS)-1A on March 17, 1988. Although its resolution of 36 meters[63] was not quite as capable as the Landsat's 30 meters, the handwriting was on the wall that foreign competitors to the commercialized Landsat system were emerging on the horizon. Another competitive threat was Russia, which began marketing high-resolution imagery in the late 1980s and early 1990s in the form of 5-meter and 2-meter resolution imagery, respectively.[64] All of these events challenged the U.S.'s lead in land remote sensing activities once held by the Landsat system. The shock of the 1986 launch and orbiting of France's SPOT satellite helped propel Congress and USG policymakers toward informed decisions to put future Landsat systems (e.g., Landsat -7) back under complete government control and financial support. Later, after the USG passed the 1992 Land Remote Sensing Policy Act, it pursued a different course for developing a U.S. CRS industry. Supportive of this new trend in thinking was the 1988 National Security Directive on National Space Policy, which called for U.S. CRS systems that could compete in the international remote sensing arena.[65]

It is important to understand that the original impetus behind the rush to commercialize the U.S. Landsat program in the 1980s was largely due to the Regan administration's desire to reduce the federal budget and its belief that the Landsat system would be more effectively developed and operated if profit motives were at its base. In this case, lack of information could not have been used as a primary excuse, since the USG had access to several reports that communicated the problems of premature privatization of the Landsat system to the Reagan administration. Despite available information sources on the subject, the Reagan administration essentially ignored such reports in favor of its interests in reducing federal expenditures and increasingly relying on the private sector to operate the Landsat satellites. In addition to ignoring three official studies commissioned by DOC in 1983 that indicated the Landsat system was not ready for commercialization,[66] Florini and Dehqanzada point out that the USG also ignored a fourth feasibility study conducted by DOC's own Civil Operational Remote Sensing Satellite Advisory Committee (CORSSAC). That study cautioned against hasty privatization or commercialization of Landsat.[67] CORSSAC concluded that the market for Landsat imagery was still immature and that privatization of the Landsat system should be accomplished over a long period of time.[68] The other three studies conducted by EOSAT, ECON Inc., and the National Academy of Public Administration essentially reached the same conclusions.[69] Not mentioned among these four studies was another substantial report produced by the Office of Technology Assessment (OTA) at the behest of the Committees on Science and Technology and Government Operations of the U.S. House of Representatives. That exhaustive study concluded that privatization could complicate the U.N.'s non-discriminatory imagery distribution principles, and thus be harmful to U.S. foreign policy interests.[70] This conclusion assumed that privatization would mean that imagery could be sold to different customers at different prices – a practice conducive to good business and marketing – thus, violating the U.N. principles and potentially causing complaints from other countries. Thus, when the 1984 Commercialization Act was passed, it included language that prohibited EOSAT from engaging in competitive pricing practices.

The OTA report revealed that privatizing the Landsat civil satellite system would be a complicated process and would involve a multitude of USG agencies with different views or perception gaps on "the appropriate means of transfer."[71] Although such perception gaps can be caused by knowledge gaps, they are also based on other factors such as ideological differences, as well as organizational goals, cultures, missions, and interests. Appropriately, Congress attempted to fill its knowledge voids on the subject by relying on OTA to conduct workshops and interviews with several knowledgeable persons (i.e., subject-matter experts). While the OTA study did not take a policy stance on whether or not to transfer the Landsat system to the private sector, it did point out several times that, should Congress pass legislation to transfer the system to a private party, it would most likely require substantial amounts of government subsidies. This was putting blind trust into USG policies and budgetary decisions to financially support the privatization experiment during its early years.

After EOSAT took over Landsat in 1985, it was forced to escalate its imagery data prices to offset shrinking revenues from government contracts and budgetary uncertainties. Still, EOSAT's revenues between 1984 and 1988 never exceeded those of NOAA in 1984. The market for earth observation imagery was not developed in the 1980s, so naturally it did not expand to provide sufficient income even if imagery costs had been lowered. Applications for Landsat imagery were also an issue during the 1980s. Although Landsat-6 would have provided more sophisticated imagery and increased demand for its data with its Enhanced Thematic Mapper (ETM) sensor, the system was not scheduled for launch until the early 1900s (and then it even failed once launched in 1993).

In the late 1980s, to publicize its desire to promote the U.S. commercial space industry, the Reagan administration issued its Presidential Directive on National Space Policy (fact sheet dated February 11, 1988) and NSPD-1 (National Space Policy Directives and Executive Charter, dated November 2, 1989). A key provision of the February 1988 directive states:

> The U.S. government shall not preclude or deter the continuing development of a separate, non governmental Commercial Space Sector. Expanding private sector investment in space by the market-driven Commercial Space Sector generates economic benefits for the Nation and supports government Space Sectors with an increasing range of space goods and services. …. Commercial Sector Space activities shall be supervised or regulated only to the extent required by law, national security, international obligations, and public safety.[72]

Although CRS satellites were not specifically mentioned in the policy, implicit in the language was the commercialized Landsat program operated by EOSAT and encouragement of future CRS systems. Unfortunately, the 1988 policy did not provide workable solutions for the ailing Landsat commercialization program. It took another four years for Congress to finally come to the realization that commercialization of Landsat was a dismal failure and that it should be returned to full government control.

The 1989 NSPD-1 policy document called for close coordination of space activities between the civil and national security sectors and the commercial sector[73] and demonstrated the administration's commitment to promoting commercial space activities and articulating its policy goals and principles, largely based on "space leadership," but also that of encouraging commercial investments in space enterprises (among which was ostensibly CRS).[74] According to NSPD-1, the USG would "encourage development of commercial systems, which image the Earth from space, competitive with, or superior to, foreign operated civil or commercial systems."[75] To implement these goals and policies, the NSPD established the National Space Council to continue studying and formulating national space policies and to monitor the implementation of such policies (to include earth remote sensing).[76]

Reagan's NSPD-1 was followed by NSPD-3 ("U.S. Commercial Space Policy Guidelines") of the George H. W. Bush administration, dated February 11, 1991, or just before what I call the transitional period for U.S.CRS. It was basically a signal to the future CRS industry to begin thinking about investing in CRS systems that would be promoted (through potential USG purchases of imagery data) but not financially supported by the USG. Most encouraging to the future CRS industry was the policy statement that:

> The U.S. Government shall avoid regulating domestic space activities in a manner that precludes or deters commercial space sector activities, except to the extent necessary to meet international and domestic legal obligations …." and that "…agencies shall identify, and propose for revision or elimination, applicable portions of U.S. laws and regulations that unnecessarily impede commercial space sector activities.[77]

However, as seen in the following period, which I call the transitional period, these optimistic pronouncements were not effectively implemented, once Congress and other USG agencies got into the act. In the annals of U.S. CRS policymaking, the privatization period serves as a classic example of a failed policy driven by an ideology and belief that the Landsat system would be more efficiently managed by the private sector to expand potential markets for land observation data and thus bring down its costs. However, that perception was inaccurate as the escalating costs of the data following the Commercialization Act of 1984 actually reduced the demand for Landsat imagery. Commenting on the failed privatization project, Williamson commented:

> The failed attempt to commercialize Landsat technology illustrates one of the great lessons of technology transfer to the marketplace: The infrastructure has to be in place before new technologies can result in successful commercial ventures. Despite the policy failures of the Landsat program, it also shows that government technology efforts can be effective in developing the basic technologies, testing them extensively, and building the knowledge base. However, a new market cannot be legislated. Private industry must find its own way into the marketplace.[78]

As can be seen, this failed policy experiment demonstrates how inadequate or defective knowledge contributed to the USG's entrenched viewpoints that the Landsat program needed to be commercialized and that such perspectives and actions were proved to have been significantly flawed.

Transitional Period (1992-Present)

In the early 1990s, the USG and CRS supporters became increasingly concerned about the position of the U.S. space industry vis-à-vis foreign governments or industries involved in developing and operating civil and commercial earth observation satellites. At the time, the only system available to the U.S. was Landsat (operated by EOSAT) and the USG's privatization experiment was faltering due to funding issues. This ultimately led to the Land Remote Sensing Policy Act of 1992,[79] a watershed law for spurring the commercial space sector into venturing into the CRS game. Reflecting concerns over increasing foreign competition and potential threats to U.S. leadership in remote sensing technology, the legislative proposal (H.R. 3614) for what became the 1992 Policy Act incorporated the following language: "Section 1. The Congress finds that – (1) although the United States pioneered the technology for the collection and application of land remote-sensing data, its leadership has eroded significantly in recent years;…:"[80]

On May 6, 1992, the U.S. Senate held hearings on the proposed Policy Act (S. 2297). Many of the hearing witnesses agreed that efforts to privatize the Landsat system since 1984 were an utter failure. For instance, Senator Al Gore, member of the Senate Committee on Commerce, Science and Transportation expressed his view on such efforts by stating, "Quite simply, the U.S. Government should not have initiated the commercialization of Landsat in the manner in which it was undertaken. … I have said for years that that was a nonsensical decision."[81] Also, according to Senator Ernest Hollings, one of the objectives of the Senate hearing was to fill a knowledge gap (i.e., "gain a better understanding") about how the privatization efforts failed.[82] Although a simplistic view, it is ironic when considering that the USG put up five Landsat satellites in just eight years before the privatization fiasco, and then once the Landsat program was ineptly commercialized, it took another nine years before an attempt was made to launch the next Landsat satellite (Landsat-6), which failed on launch. Thereafter, it took another six years to develop and successfully launch Landsat-7 in 1999, albeit, part of that time should not be counted as the commercialization period due to the passage of the Land Remote Sensing Policy Act in 1992, which placed the Landsat program back into USG hands.

Although the 1984 Commercialization Act could have served as the green light for CRS firms to enter the earth observation satellite business, the 1992 Policy Act was the landmark legislative act that prompted the CRS industry into obtaining CRS licenses and investing in CRS satellite systems. Even though the legal foundation for gaining CRS licenses in the U.S. was established by the 1984 Act, there was not a robust market or infrastructure (e.g., GIS systems, etc.) in the 1980s for any attempt to initiate a completely commercialized venture. Given the different outcomes of the 1984 and 1992 Acts, it is perhaps not surprising that, based on my extensive research of CRS policy issues, very few people who write about or discuss CRS legal or policy regimes acknowledge or perhaps even know that the 1992 Act did little to add to what was already in the 1984 Act in terms of provisions for CRS licensing. A review of relevant portions of both the 1984 Commercialization Act and the 1992 Policy Act revealed that the language on licensing conditions and procedures is almost identical to each other (See Appendix A and B of this dissertation). Yet, despite this stark similarity (almost a mirror image), many scholars, USG officials, and other CRS observers and researchers tend to credit the 1992 Act as establishing the authority of the DOC to license private satellite imaging firms.[83] That foundation was already established in 1984. What the 1992 Act accomplished was to serve as a renewal or reinvigoration of the USG's interest in and commitment to supporting the CRS sector of the U.S. space industry following the Cold War.

Although the 1992 Act sparked interest in the U.S. space industry to begin developing and operating CRS satellites, the 1992 legislation did not provide specific implementing language that was deemed important by the emerging CRS industry to encourage massive investment of developmental funds to act on any license it would obtain from the USG. In other words, it simply provided an opportunity for CRS satellite companies to seek licenses, but it did not encourage the USG to purchase CRS imagery to help the CRS industry in its early stages. PDD-23 partially corrected this vagueness in policy direction, but it took a subsequent policy (i.e., the 2003 Commercial Remote Sensing Space Policy (CRSSP) to demonstrate to existing and future CRS firms that the USG was serious about supporting its fledgling industry. Moreover, several firms that applied for CRS licenses complained that the USG was imposing excessive delays in reviewing and approving such licenses. Among other factors, such complaints prompted Congress to hold additional hearings on CRS policy and regulatory issues. The results of those hearing are covered in extensive detail in Chapter 2. As a result of a February 1994 Congressional hearing and pressure to produce a coherent policy implementing the 1992 Policy Act, the Clinton administration promptly issued Presidential Decision Directive (PDD-23) in March 1994.

In the political dynamics of U.S. CRS policymaking, legislation has usually been followed by policy statements/documents and subsequently by CRS regulations. Actually, regulations governing CRS operations were already in place in 1987 at NOAA, but they needed to be updated to reflect the changes in CRS laws and policies in 1992 and 1994, respectively. Still, it took NOAA over three years to publish its first post-1994 draft regulations (i.e., "notice of official rulemaking") on November 3, 1997, which resulted in twenty four sets of comments from the public.[84] Intergovernmental coordination on policies and regulations often moves at a snail's pace and this phenomenon can be exacerbated by the complexity of the political, economic and/or technical issues at hand and by the arduous process of interagency coordination.

In the case of U.S. CRS regulations, NOAA was unable to produce its interim final rules on CRS licensing and operations until July 31, 2000, nearly three years after the initial draft regulations were issued. Once the interim rules were issued, NOAA allowed a mere thirty days for public comments.[85] Later, based on new changes in CRS policy (i.e., CRSSP) issued by the George W. Bush administration in 2003, NOAA issued proposed amendments to the licensing rules on May 20, 2005. NOAA finally issued its final set of regulations on April 25, 2006. Thus, it took almost nine years after the initial 1997 regulations to issue final regulations implementing the CRS parts of the 1992 Land Remote Sensing Policy Act. Perhaps pressure for more expedient actions by NOAA would have made a difference. To be fair, NOAA cannot be entirely faulted for this delay. Not only did NOAA need to seek public comments on its proposed regulations, it also had to seek concurrence from other USG actors (e.g., NSC, DOD, DOS, IC, USGS, etc.), and anyone who has experienced the USG policy coordination process knows how long that can take. Furthermore, NOAA had to amend its draft regulations to comply with the new 2003 CRSSP that replaced PDD-23. Unfortunately, neither the 1992 Act nor PDD-23 (at least, according to its fact sheet) mandated a deadline for accomplishing the task of producing definitive regulations for the CRS industry. The 1992 Act only states in Section 5624 (Regulatory authority of Secretary [DOC]) that "The Secretary *may* [italics mine] issue regulations to carry out this subchapter."[86] It is my contention that these types of delays were, in part, the result of political infighting, divergent perspectives on CRS issues, coordination difficulties, and knowledge gaps about the multidimensionality of U.S. CRS, as further elaborated throughout this dissertation.

In early 1993, as the 103rd Congress began its committee work, the Subcommittee on Space of the House Committee on Science, Space, and Technology, held hearings in February to discuss issues affecting the U.S. space industry (of which remote sensing is a small component). Although records of the hearing showed that the focus was mainly on the space station and launch capabilities, they also provided significant insights into how Congress works to legislate and fund space programs such as remote sensing. An example of space program funding by the USG can be seen in 1992 when Vice President Dan Quayle appointed a standing Space Policy Advisory Board (SPAB), which provided advice to him on issues concerning commercial space programs. Yet, despite these noble efforts to more actively promote space and CRS programs in the early 1990s, many CRS supporters were not optimistic about policies and programs to promote the U.S. space industry. For instance, at a February 1993 hearing by the House Subcommittee on Science, Laurel L. Wilkening, Provost and Vice President for Academic Affairs of the University of Washington, commented negatively about government stewardship of U.S. space programs, opining that "…numerous Government regulations and laws foster inefficiency and contribute unnecessarily to cost and complexity. In some case they even prohibit the use of Government-funded space systems and technology for commercial applications."[87]

Perturbed by the delays in CRS licensing approval by NOAA, Congress held a joint hearing in February 1994 to determine the reasons for inaction by the executive branch and lack of a coherent policy promoting the U.S. CRS industry as called for in the 1992 legislation. The political dynamics of that hearing are discussed in detail in Chapter 2. PDD-23 was issued about a month after the Congressional hearing and chastisements of the Clinton administration. Even during the previous year, concerns had been expressed about ineffective policies to promote the U.S. space industry at large. For example, a statement by Jerald S. Howe, Jr., Sr. Vice President and General Counsel of Veridian, Arlington, VA, before a 1993 Congressional hearing on the future of the U.S. space industrial base, made it quite clear:

> The question is what type of policy will we have. Will the policy be a disorganized aggregation of measures taken across the board by a hodgepodge of different agencies – or will it be a concerted effort to engage the Government in ways it can be productive in technology and industrial development, and to keep it from taking actions that will be counterproductive.[88]

Despite conflicts within the USG concerning CRS policies and regulations, the U.S. CRS industry took the initiative and began developing high-resolution (5 meters or less) CRS satellite systems, in response to the 1992 Policy Act and PDD-23. On December 25, 1997, EarthWatch, Inc. (now called DigitalGlobe) launched the first U.S. CRS satellite, EarlyBird, but it stopped operating after about three days. Another firm (Space Imaging) met the challenge by launching its Ikonos satellite on April 27, 1999, but Ikonos also failed to reach orbit. Not to be deterred, Space Imaging quickly recovered by successfully launching a second satellite, Ikonos-2, on September 24, 1999. Two years later, EarthWatch (DigitalGlobe) got back into the game by successfully launching its second QuickBird satellite on October 18, 2001,[89] but only after the launch failure of its QuickBird-1 in November 10, 2000.[90] Finally, Orbimage completed the high-resolution CRS act by successfully placing its high-resolution Orbview-3 into orbit on June 26, 2003.[91] Yet, Orbimage was also not immune to the significant technological challenges faced by other CRS companies attempting to launch extremely expensive satellite systems into orbit. Almost two years prior to the successful launch of its Orbview-3 satellite (currently in orbit but no longer operational), Orbimage suffered a launch mishap when its Obview-4 satellite failed to achieve successful orbit on September 21, 2001.[92] While both Orbview-4 and Orbview-3 were scheduled for launch in the 2001 and 2002, respectively, Orbview-3 was delayed due to manufacturing problems since 1999.[93]

The policies of U.S. CRS have almost been as inauspicious and problematic as the aforementioned technical mishaps. Moreover, it is not readily apparent (at least to this author) that the economic impact on and financial devastation of the U.S. CRS sensing industry due to such technological misfortunes has been well understood by many in the USG responsible for producing CRS policies and regulations. To fill knowledge gaps concerning the U.S. CRS industry, NOAA commissioned a study by RAND to (in part) research and analyze the technical risks faced by the nascent CRS industry at the turn of the 21st century.[94]

In 1996, international politics entered the U.S. CRS policy arena in a significant way when Israel began lobbying the USG concerning the future technical capabilities or operations of U.S. high-resolution satellites. At the time, three U.S. firms had already been granted licenses by

DOC (NOAA) to operate 1-meter panchromatic CRS satellites.[95] Israel was particularly concerned that high-resolution imagery of its key military installations and military movements within its borders would compromise its security and make it vulnerable to attacks by its adversaries. Such concerns began shortly after the passage of the Land Remote Sensing Policy Act in 1992. One major point of concern was the United Arab Emirates' desire to purchase a CRS satellite system from a U.S. Company, Litton Itek, in late 1992.[96] Israeli concerns were further exacerbated when a Saudi firm, EIRAD, sought to acquire a major financial interest in the Eyeglass venture.[97] As a consortium involving Orbital Sciences, GDE, and Itek, Eyeglass International had received a license for a 1-meter system from DOC in 1994.[98]

After a significant amount of discussion and diplomatic jockeying between U.S. and Israeli officials, the U.S. Senate passed an amendment (known as the Kyl-Bingaman Amendment and discussed in more detail in a subsequent chapter) to the 1997 Defense Authorization Act that would restrict U.S. CRS licensees from imaging Israel or other designated areas unless the imagery was no better than what was offered by other non-U.S. commercial satellite systems. According to Middle East CRS expert, Gerald Steinberg, Israel agreed to a 2-meter limit (since the Russians were already marketing imagery at that degree of clarity), but protested against the 1-meter capabilities to be offered by already licensed U.S. CRS firms.[99] Essentially, this agreement was a politically motivated form of shutter control to be imposed on the U.S. CRS industry. "Shutter control" is a euphemism associated with provisions of PDD-23 (now replaced by CRSSP but with the same provisions) and current U.S. CRS licensing regulations that authorizes the USG to temporarily limit the imaging operations of U.S. CRS satellites when U.S. national security is at risk. An example of shutter control would be an order by DOC (based on recommendations by the national security or foreign policy community) to U.S. CRS operators to turn off their satellite imaging sensors when viewing specific areas on the globe where U.S. military operations are occurring or are about to occur. The 2-meter agreement between the U.S. and Israel was a shutter control-like measure, albeit permanent in nature and favoring a single country. Of course, the 2-meter limit is no longer valid since there are several foreign CRS systems now in operation that have better than 2-meter resolution.

Another policy milestone during the CRS transitional period was the Commercial Space Act of 1998. Similar to the Policy Act of 1992, the Commercial Space Act of 1998 went though several versions before being signed into law in October 1998. The Act was intended to stimulate the U.S. commercial space industry, which among other activities included CRS. Pre-legislation hearings on this subject manifested the oft-contentious issues associated with U.S. CRS operations. Section 107 of the Act specifically directed NASA to purchase CRS imagery data useful for earth science research[100] (which was later covered in NASA's Earth Science Enterprise program, as discussed in more detail in Chapter 3). The two key provisions of the Commercial Space Act were sections that amended the 1992 Policy Act, directing that within six months of the Act DOC would produce complete CRS licensing procedures and guidelines for NASA's purchases of CRS imagery for its Science Data Buy program.[101]

A few years after the passage of the Commercial Space Act, the USG decided it needed an interagency agreement to clarify how it would coordinate licensing and shutter control actions. On January 4, 2000, the USG concluded a memorandum of understanding (MOU) concerning CRS licensing and shutter control procedures. Signatories of the MOU were the heads of

Departments of Commerce, State, Defense, Interior, and the IC.[102] In its section on procedures, the MOU reiterated the review timelines for licensing applications. Further, among the key provisions of the MOU were the stated procedures for implementing shutter control restraints on US-licensed CRS satellite systems, whereby the Secretaries of Defense or State could advise the Secretary of Commerce that U.S. CRS imaging operations should be interrupted at specific times and places to protect U.S. national security, international obligations, or foreign policies. If the Secretary of Commerce disagreed with such recommendations, he/she would refer the matter to the Assistants to the President for National Security Affairs and for Science and Technology, who would then attempt to reach consensus among government stakeholders. Barring consensus, the matter would be submitted to the President for a final decision.[103]

A year later in 2001, the George W. Bush administration established a Space Policy Coordinating Committee (Space PCC) with the mission to "coordinate national space policy matters affecting multiple agencies of the federal government."[104] A most important aspect of the Space PCC's role in space policy coordination is seen in its June 2000 tasking to complete a Space Policy Review. One of the Space PCC's accomplishments was the 2003 U.S. Commercial Remote Sensing Space Policy (CRSSP).[105] A copy of the 2003 policy is included as Appendix E of this dissertation. The U.S. CRS industry hailed this new policy as an important milestone in promoting U.S. CRS activities.[106] Commenting on CRSSP, Dennis Jones, Director of the Center for Space Policy and Strategies in Arlington, Virginia, noted that "The Bush administration's policy also offered a more aggressive U.S. Government approach to commercial remote sensing by defining what role commercial imagery would play in satisfying government requirements."[107]

Although CRSSP maintained the duality of balancing national security interests with economic stimulation of the U.S. CRS industry, it went a step further than PDD-23 (which was rescinded by this new policy) by requiring USG agencies to increasing rely on CRS imagery for their mission needs, develop closer ties with the U.S. CRS industry, and most importantly, to "provide a timely and responsive regulatory environment for licensing the operations and exports of commercial remote sensing space systems, …"[108] The latter component of this provision obviously prompted NOAA to issue amendments to its May 2000 interim regulations. The CRSSP also prodded DOD into revisiting its policies on CRS imagery utilization. As a result, the National Imagery and Mapping Agency (NIMA; now NGA) announced on January 17, 2003 the awarding of two CRS imagery purchase contracts called ClearView.[109] One of those contracts went to Space Imaging and was worth $120 to $500 million for a three-year baseline period and two optional years.[110] The other contract for the same performance period was awarded to DigitalGlobe and was worth $72 to $500 million.[111] Later in October 2003, NGA awarded another CRS imagery purchasing contract called "NextView Digital Globe" to DigitalGlobe.[112] The following year, in October 2004, NGA awarded a similar contract called "NextView ORBVIEW" to Orbimage.[113] Space Imaging had competed for the 2004 contract but lost out to Orbimage due to inability of NGA and Space Imaging to come to agreement on funding issues.

Lucrative NGA contracts aside, one of the more productive achievements of the transitional period was the establishment by NOAA of the Advisory Committee for Commercial Remote Sensing (ACCRES) in 2002.[104] That event was a huge milestone in attempting to fill knowledge gaps in CRS policymaking. During my research for this dissertation, I had the chance to attend four open sessions of the ACCRES meetings. According to its mission statement, ACCRES:

> …provides information, advice, and recommendations to the Under Secretary of Commerce for Oceans and Atmosphere on matters relating to the U.S. satellite commercial remote sensing industry and NOAA's activities to carry out the responsibilities of the U.S. Department of Commerce set forth in the Land Remote Sensing Policy Act of 1992 (15 U.S.C. Secs. 5621-5625).[115]

The role and effectiveness of ACCRES in advising CRS policy is detailed in Chapter 3. The most recent charter for ACCRES was signed and filed with appropriate Congressional committees and the Library of Congress (thus officially re-establishing the committee) on May 2004. The charter specified that, unless authority was renewed, ACCRES would terminate in May 2007.[116] Since its establishment in 2003, ACCRES has held eleven meetings. Minutes of open sessions for all meetings, except the July 22, 2003 task group meeting, were available for review and were used to produce parts of this dissertation. The ACCRES minutes and reports provided a wealth of information about the perspectives of government officials, CRS industry representatives, academics, and other CRS proponents concerning CRS licensing and policy issues. The documents also helped identify endemic knowledge gaps in understanding the complicated aspects of CRS and its policymaking ramifications.

During my research, I concluded that ACCRES was one of the most effective organizations attempting to bridge such knowledge gaps, which will be discussed in greater detail in the following section. In addition to providing extremely informative briefings, ACCRES has requested and/or supported significant studies such as a five-year projection of international land-imaging satellite systems,[117] an Organisation for Economic Co-operation and Development (OECD) report on international space activities (which contained sections on earth observation activities),[118] and two major studies on the aerial remote sensing industry (a significant competitor to the space CRS industry) and the international market for remote sensing imagery conducted by Global Marketing Insights, Inc.[119] Reflecting on part of the theme of this dissertation, "Conflict and Collaboration" in the political arena of CRS, I assessed ACCRES's activities to be significant steps towards filling CRS policy-related knowledge gaps and providing a forum for government-industry collaboration on complicated CRS policy and regulatory issues.

Knowledge Void/Perception Gap Hypothesis (Effects on U.S. CRS Policies)

One of the objectives of this dissertation is to examine and analyze the policy issues and perspectives of key players in U.S. CRS operations to determine if, or to what extent, such perspectives are influenced by knowledge voids. A survey of the STS literature revealed little to no research on the relationship between CRS policy deficiencies and a corresponding lack of knowledge or understanding of the complex issues affecting the CRS industry in the past decade. Thus, during research for this dissertation, attempts were made to determine if knowledge gaps are commonplace regarding the legal, political, economic, and technological aspects of CRS and, if so, to what extent they potentially influence perceptions on how best to promote and regulate the U.S. CRS industry. This objective entailed three tasks. The first was to identify CRS-related knowledge gaps and determine their pervasiveness. The second was to determine what caused such knowledge gaps. Preliminary findings of this study suggest that the sheer complexity of CRS with its manifold dimensions (legal, political, economic, international, technical) potentially contributes to such knowledge voids. The third task was to determine if such knowledge gaps potentially affect perceptions and opinions on how best to promote the U.S. CRS industry while simultaneously controlling or regulating its activities to meet U.S. national objectives such as national security, foreign policy, and international obligations. In doing so, no attempt was made to draw a strict cause-and-effect relationship between knowledge voids and perception gaps. Such an endeavor, though potentially fruitful, would have been beyond the scope of this dissertation and would require analytical techniques used in such disciplines as cognitive science and psychology. However, it seems likely that both knowledge gaps and ideology can contribute to perception gaps on policies relating to the management and control of CRS technology. More importantly, this study aims to identify the frequency and magnitude of knowledge gaps and to determine, wherever possible, their causes and ultimately offer recommendations and suggestions for filling such gaps.

In several instances, the terms knowledge void, knowledge gap, or knowledge defects are used in this dissertation to mean both a lack of knowledge of factual data or information and indicators of such knowledge gaps, particularly as reflected in stakeholder statements concerning the various aspects of CRS policy issues. In the context of this study, perception gaps are differences in viewpoints or opinions regarding the nature of CRS and how it should be promoted and regulated. Such gaps are reflective of differences in interests, goals, cultures, sociopolitical positions, and interpretations of one's own knowledge base. Yet, when it comes to interests, a slight divergence is worth explicating. Both the CRS industry and the national security community would say that they have an interest in CRS, but their perceptions on how those interests can and should be met are often different and conflicting. Obviously, industry stakeholders are interested in the commercial aspects of CRS, whereas security proponents are interested in restricting the technology as much as possible or calling for their own exclusive access to CRS imagery. Sector differences also come into play in this arena of competing interests: Industry is obviously interested in making CRS profitable; transparency advocates such as the media, scientific researchers, and non-governmental organizations (sometimes called "imagery activists") are interested in relatively unfettered access to CRS imagery; and national security institutions are generally interested in restricting such unfettered access. Although somewhat problematic, if one wants to call these sectors "interest blocs," there are even divergent perspectives within each of those blocs but usually not as stark as across the sectors.

Perception gaps often stem from or are indicative of political and policy conflicts. CRS-related perception gaps are also differences in views concerning the national and global impact of CRS on international relations, military operations, scientific research, and other socio-economic activities. The phenomenon is similar to the theories of technological design (called the social construction of technology or SCOT)[120] of Wiebe Bijker, Thomas Hughes, Trevor Pinch, and Donald MacKenzie, and other STS scholars. MacKenzie used SCOT theories by including the political dimensions of technology in his analysis of how U.S. missile guidance systems were created and developed. Here, it is important to state at the outset that any knowledge-perception gap relationship, as related to CRS policymaking, does not exclude a myriad of other determining factors such as individual or group interests, institutional cultures, organizational missions, and world views/social worlds, etc. It simply introduces knowledge gaps as an additional factor that is not well studied or discussed in the extant literature on U.S. CRS policymaking.

While filling knowledge voids will not necessarily eliminate perception gaps or divergent policy positions, there is always a chance that expanding one's knowledge about CRS can alter one's ideology, perspectives, or political agendas regarding CRS policy issues, if one is cognitively flexible and open minded about such issues. Filling CRS-related knowledge voids can make contentious CRS policy debates more informed and potentially lead to closure in policy conflicts, as evidenced by more industry-friendly CRS policies and regulations since 2003. Yet, it is important to recognize that increasing one's knowledge could reinforce one's original perspective, instead of modifying it, and thus lead to increased conflict or forestall closure of CRS policy debates.

Lack of familiarity with the myriad details of CRS policy issues and divergent perceptions on both sides of the government-industry divide in the CRS arena seem to have been at the root of many of the early and even recent problems in crafting effective policies and regulations for CRS operations in the U.S. If government policymakers and the CRS industry were well informed and educated about each other's challenges, frustrations, and obligations, the U.S. would be in a better position to formulate a policy regime that both protects national security and effectively promotes the economic viability of the U.S. CRS industry. Such a goal could be achieved if the U.S. CRS industry gained a deeper understanding of the politics involved in promoting and regulating its activities, while USG policymakers and CRS regulators gained a similar awareness of the technological and business challenges of CRS. Of course, there still might be policy conflicts, but an increased knowledge base for all CRS stakeholders could make such policy conflicts more manageable.

Figure 1 helps one visualize the concept of how knowledge voids potentially create perception gaps leading to ill-informed and ineffective government policies for promoting and regulating the U.S. CRS industry. The visual aid is not just a hypothetical model. Instead, it portrays the key issues that have affected the political and bureaucratic environment in which U.S. CRS laws, policies, and regulations have been crafted, developed, and refined. On the left side of the model, we have detailed knowledge of how CRS imagery can be problematic if used for malevolent purposes, which potentially leads to the perceptions or opinions that CRS imaging capabilities and operations must be strictly controlled. On the right hand side of the model, we have detailed knowledge of the multiple applications of CRS imagery data to benefit science and other sectors of society, which potentially leads to perceptions or opinions that CRS imagery capabilities and operations must be as unencumbered as possible. Much of the literature on CRS policy issues characterizes this dichotomy of awareness and viewpoints as competing interests between security concerns and desires for openness and transparency of information.

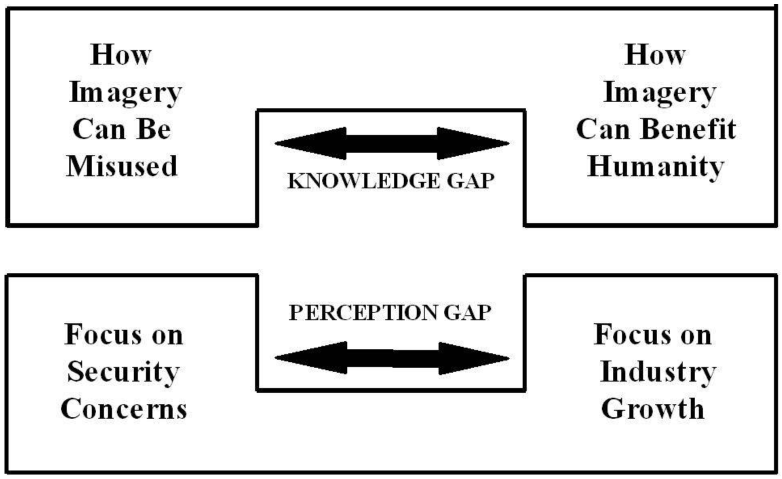


Figure 1 – Conceptual Relationship between Knowledge Gaps and Perception Gaps

This knowledge-perception gap model raises the question: How does deficient knowledge lead to perception gaps or even faulty perceptions and potentially to particular courses of action that could have been avoided if correct knowledge existed in the first place? More specifically, how do CRS-related knowledge gaps influence or affect USG efforts to legislate and regulate CRS activities, leading to the development and implementation of less than effective laws, rules, and policies? Answers to these questions led me to base my premise on the notion that, among other contributory factors, knowledge drives or forms perceptions and the latter substantially influence policy decisions. Chapters 2 and 3 detail how perceptions (based on issues of national security, diplomacy, international obligations, international market competitiveness, etc.) influence the crafting of CRS-related laws, policies, and rulemaking.

Relationship between Knowledge Voids, Perception Gaps, and Human/Sociopolitical Actions: Hypothetical and Historical Examples

To demonstrate how knowledge or lack of such potentially contributes to the shaping of perceptions, it is instructive to envision a simple scenario or example of faulty knowledge leading to faulty perceptions and, consequently, to adverse or ill-informed actions. After offering a hypothetical example of this phenomenon, an actual case of CRS-related knowledge gaps leading to faulty perceptions and flawed policy decisions is examined to demonstrate the linkage between these three states or phases of the CRS policymaking processes.

<u>Notional Example</u>

Assume for a moment that a pedestrian is walking outside of an abandoned building in a slum area of a large city. As that pedestrian passes by the building, she/he hears a loud noise and, assuming it comes from inside the building, stops and turns her/his attention toward the building. At that precise moment, the pedestrian (which happens to be an off-duty police officer) observes a large, swarthy looking man, dressed very shabbily, come running outside the building toward the policeman. The person emerging from the building appears to be clutching an object resembling a handgun. The policeman automatically assumes the person emerging from the abandoned building has just committed a crime inside the building (perhaps shooting someone inside). As a result, the police officer draws his weapon and orders the other man to stop. The latter individual raises his hands but does not drop the object in his hand, whereupon he is shot dead by the police officer. Later, it was determined that the person shot was a homeless person. It was also determined (according to a witness who stopped during the incident) that the loud noise was a backfire from the not-so-well-tuned car of the driver/witness. As was later learned, the driver was approaching the building when his car backfired. As he passed in front of the building he observed one man running out of the building and another man aiming and shooting at the man emerging from that building.

This tragic, yet fortunately hypothetical example of an accidental shooting occurred because the homeless man heard what he thought was a shot and assumed that someone was shot outside his temporary shelter (the abandoned building). Thus, he picked up a pipe and rushed outside to assist the victim of a perceived gunshot. Of course, this action was probably impractical because a pipe is no match for a gunman. Moreover, the off-duty policeman incorrectly assumed the noise was a gunshot coming from inside the building and mistakenly identified the man rushing out of the building as an armed perpetrator. There is an old adage to goes somewhat like, 'Assumptions are the mother of all mistakes.' Although this is a very simplistic example, it illustrates how incomplete knowledge can lead to ill-informed perceptions and false conclusions.

Of course, this notional example might be considered a far cry from one that has a connection between knowledge voids, perception gaps, and ineffective policies related to U.S. CRS activities. This case required immediate action without reflecting on extant knowledge resources, as would be done in deliberations on CRS policymaking. Moreover, other factors come into play in U.S. CRS policy decisions, instead of the immediate exercise of existing knowledge assets. Although the parallels in logic (as suggested in the above fabricated example) are not necessary closely aligned (i.e., an assumed parallel correlation), such example is used to provide a sense of how knowledge or lack of such can create or influence perceptions and opinions that affect CRS policy decisions and regulator regimes.

Actual Example

One actual example or historical case that occurred during the "privatization" period of U.S. CRS demonstrates how knowledge voids contribute to perception gaps and ultimately to a failed commercialization policy for U.S. earth observations systems (i.e., Landsat-4 and -5). In the early 1980s, just prior to and during the USG's attempts to privatize the Landsat system, there appeared to be extensive knowledge gaps concerning the economic viability of a commercialized Landsat program. Privatization advocates labored under the misconception that the inevitably increasing prices of imagery data (should a private firm take over the Landsat system and make a profit without having to rely on government subsidies, which the USG was trying to avoid over the long run with its new policy direction) would or could be paid for by the then small data user community (to include the USG). Mistakenly, privatization proponents assumed that the non-governmental market for CRS imagery would expand rapidly enough for the commercialized Landsat operator (EOSAT) to stay in business. Yet, as mentioned above, several studies attempted to fill this knowledge void by advising the USG that the remote sensing market was not yet ready for commercialization and would not be ready for several years in the future.

Perhaps the most colossal knowledge gap-influenced policy perception at the time was OMB's belief and ideology that privatization could work in the short term. According to Lauer, "OMB held steadfast to the notion that if the [Landsat] program had true merit then it should be able to pay its own way…."[121] Such beliefs were based on very simplistic thinking and possibly not understanding that, just because a technology has merit, it will not necessarily be commercially profitable in the short term, long term, or even at any time. This lack of understanding contributed to perceptions of the Reagan administration that the Landsat program could indeed by privatized in the 1980s. Other knowledge gaps at the time were lack of understanding of the "public good" aspects of the Landsat program by OMB and other high-level administration officials.[122] Such knowledge voids were seen as a major impediment to effective policy development.[123]

Perceptions that privatization or commercialization would be feasible for the Landsat program can be traced back to President Carter's 1978 Presidential Decision 42 (PD-42), which "mandated the active consideration of greater private sector involvement in remote sensing activities…."[124] PD-42 was followed by Carters' Presidential Decision 54 (PD-54), which outlined the USG's goals for privatizing the Landsat system. Some administration officials believed that, under NOAA's management, the user base for data would eventually mature to a point that private firms could fund, develop, and operate their own remote sensing systems for both the government and the private market's needs.[125] Such perceptions led OMB to believe that system costs could be recovered and profits made through data sales. Others believed that the USG would continue to fund government purchases of Landsat imagery, which would necessarily accelerate in costs, while the private venture of EOSAT would gradually wean itself from USG subsidies for data purchases by selling imagery data to a growing market believed to be hungry for CRS data and information.

Based on knowledge voids (and other factors) and faulty perceptions in the early 1980s, the USG proceeded to implement its commercialization goals, culminating in the passage of the Commercialization Act of 1984. That Act and its implications were later called a shortsighted and defective piece of legislation. For example, Lauer called the post-1984 privatization program as one in "crisis" and involved a patchwork of emergency funding measures to keep the privatization efforts afloat.[126] Further, James H. Scheuer, Chairman of the Subcommittee on Environment of the House Committee on Science, Space and Technology, viewed the commercialization project as operating within a fairly unsuccessful policy framework.[127] Many other knowledgeable experts have come to similar conclusions in their analysis of this tragic period in the history of U.S. civil and commercial remote sensing programs. Of course, one could ask: Were knowledge voids the only (or main) determinants of (or contributors to) the failed policies? The answer is obviously no. However, it is easy to believe that, had there been greater awareness or knowledge of the complex nature of private-sector demands for remote sensing data and the ability of users to pay the escalating costs of land observation satellite data, there might have been more restraint on the part of the Reagan administration in its incessant desire to commercial the Landsat system. Essentially, the market for remote sensing imagery was small during the 1980s and did not grow as expected by the Reagan administration. Several studies that predicted problems with the privatization strategy, which intended to fill knowledge voids in CRS policymaking, were obviously misunderstood or ignored. Notwithstanding, there were other pressures on the U.S. budget, such as funding defense programs during the Cold War, resulting in Congress scrambling to find a way to save the Landsat program and privatization seemed the only recourse.

Obviously other factors were in play in addition to knowledge voids and such factors contributed to the policy fiasco. Primary among them was NOAA's 1986 decision not to continue funding the commercialization efforts,[128] technical problems, and ongoing conflicts between the Reagan administration and Congress over how best to keep Landsat commercialization alive. Other factors consisted of inconsistent government funding of imagery purchases and development of future Landsat systems, as if the USG were reacting to current conditions, instead of operating on a well-conceived plan from the outset of the privatization period.

Implications of the Knowledge Void-Perception Gap Phenomenon

Knowledge of the impact of USG policies and regulations on U.S. CRS activities is crucial to the success of the CRS industry and, conversely, lack of knowledge or comprehension of these implications creates undesirable results. According to a 2001 Rand study (commissioned by NOAA) of the risks faced by the CRS industry, "success for these new U.S. commercial remote sensing satellite firms heavily depend on both *understanding* [italics mine] and overcoming various risks (e.g., technical, market, policy and regulatory) in the highly competitive global marketplace for geospatial information products and services."[129] Such knowledge gaps can exist in both the government and industry – or put differently, in the cultures described by Scott Pace as the "guardians and merchants."[130] – or even among scholars and others observers of remote sensing policy issues.

How deep and pervasive are CRS knowledge gaps? To what extent does either side comprehend the policy risks involved? Precisely measuring knowledge and appreciation of policy influences/impacts on U.S. CRS technology and operations is extremely difficult, if not impossible. Still, one can get a sense of this phenomenon through analysis of the actors' cognitive grasps of the technological and political aspects of CRS throughout its short history, as represented by what participants and observers have expressed about the field of CRS. As I demonstrate throughout this dissertation, such knowledge gaps are due in part to the sheer complexity of the subject matter of CRS. Obviously, acquiring substantial and accurate knowledge of CRS policy issues requires a significant amount of study of the political, economic, historical, and technological dimensions of the field. One of the objectives of this dissertation is to contribute to such an understanding and generate new knowledge on the subject by introducing and applying the theory of knowledge voids and its relationship to CRS policymaking – an approach that appears to be lacking in the current STS and public policy literature. Acquiring more knowledge of the multiple aspects of CRS was seen as an important goal in the numerous CRS forums that I attended but I did not detect an understanding (or hear expressions of comprehension) of the possible connection between knowledge voids and policy decisions through the conduit of perceptions and ideology. Although an ambitious vision, recognition of the role of knowledge voids (among several other causative factors) in determining or influencing policy perceptions and decisions could lead to strategies for reducing such voids to facilitate more informed and efficacious CRS policy negotiations (and hopefully other S&T policies).

Existing Knowledge Sources on the Politics of CRS

Although a significant amount of literature exists on U.S. CRS policy issues, very little is mentioned therein about the concept of knowledge gaps and how they influence or drive perceptions in CRS policymaking. Most of the relevant literature is in the form of papers, articles, reports, and government documents. During research for this dissertation, I encountered what I would characterize as four major works on the political and policymaking aspects of CRS, which among other sources of information on CRS policy issues, significantly contribute to the understanding of the political, policy, and economic dimensions of U.S. CRS and potentially fill knowledge voids on this complicated but important subject area. The earliest STS-oriented monograph on the Landsat program was Pamela Mack's dissertation-turned book (1990) entitled *Viewing the Earth*: *The Social Construction of the Landsat Satellite System*. Mack used an STS approach in her dissertation and book to survey the political and bureaucratic history of civil remote sensing satellite, Landsat.[131] Mack traced the pre-1984 period of the Landsat satellite system and concluded that it is important to understand and integrate the interests of multiple actors and stakeholders in U.S. remote sensing enterprises to produce and operate U.S. earth observation satellite systems. Key to this understanding is an analysis of competing bureaucratic interests (a subject that will be covered in detail in chapter 2 of this dissertation). Although Mack's study generally covered the pre-1984 period of the Landsat system, when it was yet to be commercialized or privatized, it is a classic case study for gaining insights into the bureaucratic politics of remote sensing and for understanding the relationships between remote sensing system developers, imagery producers, and imagery users. In Mack's case, that would generally be the government for all three functions. In my case study of the politics of CRS (i.e., the post-1984 period), these roles and functions switch to the CRS industry (as developers and producers of CRS systems and imagery data, respectively), government entities (as crafters of CRS laws and policies and major consumers of U.S. CRS imagery), and to a lesser extent, the community of scientists, researchers, and non-governmental organizations and interest groups that use CRS data and imagery.

Following Mack's monumental study, Donald Lauer wrote a substantial dissertation in 1990 that assessed USG's policies for the Landsat program and the USG's ill-fated attempts to commercialize that system.[132] Essentially, Lauer conducted a critical review of the USG's policies for commercializing the Landsat system and concluded that it was a failure and did not meet a majority of the objectives of the USG's privatization program. Lauer offered several recommendations to improve those policies and submitted them in the form of a letter to President George H.W. Bush. Most instructive of his recommendations was that the Landsat system should be returned to government control and that DOI would be the logical USG organization for operating the Landsat system. The USG actually took that route (although it is not known if Lauer's letter was a factor) when it transferred operational control of the Landsat satellites from NOAA to the U.S. Geological Survey (USGS) of DOI in 1998. Still, uncertainty (likely driven by knowledge voids) as to where to lodge the Landsat program has been pervasive during its more than two decades' long history. Landsat was first operated by NASA; then transferred to DOC (NOAA); then turned over to the private firm EOSAT; later assigned to NASA, NOAA, and DOD; and finally given to DOI (USGS). Lauer touched on this very briefly in his dissertation: i.e., that NOAA's mission was oceans and atmospheric monitoring and not land imaging,[133] as the agency was unfamiliar with and uninterested in land remote sensing. Such assignment could be construed as a knowledge void on the part of the USG and Lauer questioned the USG's decision to put DOC in charge of the Landsat program.[134]

In the case of the Landsat program, constant changes of agencies potentially contributed to knowledge voids or lack of policy insights into how best to manage the U.S.'s premier medium-resolution land imaging system. Every time a new agency takes over management of a large technological program, its people face a steep learning curve. It is easy to interpret the shifts in Landsat management to be based in part on knowledge voids concerning which agency was best suited for Landsat operations. Moving Landsat-7 back to DOI (USGS) in the late-1990s was the smartest move but one wonders why it took so long to realize this. Amazingly, it took forty years to come full circle. NOAA is an agency that deals with the oceans and atmosphere. Landsat is a land imaging satellite, and land monitoring is a mission of the USGS, not NOAA. In fact, it was DOI that first proposed the Landsat system back in the 1960s. Of course there were other complicated factors that caused these agency shifts, which were well covered by Lauer prior to 1990 and by Baker, O'Connell and Williamson after 1990 (their book is discussed below). NOAA operates weather satellites and the USG assumed that that agency would be knowledgeable about and interested in (or best suited for) operating a land imaging system.

In addition to Mack's and Lauer's tremendously insightful treatises on the socio-political history of U.S. remote sensing, the most valuable study on U.S. CRS is a book jointly published in 2001 by RAND and the American Society for Photogrammetry and Remote Sensing (ASPRS), entitled *Commercial Observation Satellites: At the Leading Edge of Transparency*.[135] That monumental work edited by John Baker, Kevin O'Connell, and Ray Williamson is perhaps the most current and extensive survey of the U.S. and global CRS industry and USG/foreign policies that govern the operation of civil and commercial earth observation systems. The landmark study provides a detailed analysis of the dynamics of U.S. CRS policymaking during the 1990s and a broad survey of foreign CRS systems and how they compete with the U.S. CRS industry. Yet, since CRS is a rapidly developing field of activity (technologically and politically), that 2001 book is rapidly becoming outdated. Thus, one of the goals of this dissertation is to partially fill that knowledge vacuum.

From a foreign perspective on U.S. CRS laws and policies, James Keely and Robert Huebert compiled reports based on a Canadian conference on CRS imagery to produce a book entitled *Commercial Satellite Imagery and United National Peacekeeping: A View From Above* in 2004.[136] Although the book provides significant insights into the potential uses of CRS imagery, especially in U.S. peacemaking/peacekeeping roles, it contains a number of factual errors (knowledge void indicators) that one needs to identify and disregard. Several of the chapters provide information that supports my knowledge void hypothesis (since it contained identifiable knowledge void indicators), which will be discussed in greater detail throughout my remaining chapters (especially in Chapter 4 and the appendices of this dissertation).

Aside from these monumental works on CRS policymaking, one needs to review numerous reports, journal articles, government documents, and material on the Internet to identify and analyze the political and bureaucratic aspects of U.S. CRS activities and related gaps in knowledge concerning the highly esoteric and complex nature of CRS and its influence on U.S.

and global political, social, and economic scene. Key among those reports is a 2001 RAND study on the U.S. CRS industry, markets, and policy/regulatory regimes entitled *U.S. Commercial Remote Sensing Satellite Industry: An Analysis of Risks*.[137] That study was commissioned by NOAA to fill its knowledge gaps on the technological, policy, and regulatory risks faced by the U.S. CRS industry. RAND concluded that policy or regulatory risks to the CRS industry were significant and that devising and implementing effective CRS policies was very difficult due to the complex nature of the relationship between the USG and the U.S. CRS industry, with the former serving as patron, supporter, regulator, and potential competitor to the latter. The aforementioned knowledge sources were extremely useful in producing this dissertation and they provided a wealth of information that helped to develop the heretofore little discussed concept of knowledge voids in U.S. CRS policymaking.

Summary of Subsequent Chapters

To analyze the politics of CRS and gain insights into the divergent perspectives on how best to promote the U.S. CRS industry while simultaneously protecting the national security and foreign policy interest of the U.S., a wide array of policy issues and organizations are covered in Chapters 2 and 3. Chapter 2 addresses issues that often divide the stakeholders in CRS policymaking (i.e., CRS industry, government, and others with interests in U.S. CRS activities). Such issues run the gamut from national security concerns, to shutter control restraints in CRS policies and regulations, to the desire for more increased openness and transparency of CRS imagery data. It also covers the highly esoteric subject of spatial resolution capabilities of CRS satellites and challenges that the technological aspects pose for CRS policymaking. Throughout the chapter, examples of policy conflicts and knowledge voids that possibly affect or cause such conflicts are identified.

In Chapter 3, I extend the study of the politics of CRS by examining the stakeholders themselves and their relationships with each other, some of which are contentious and some of which are collaborative in nature. Assuming collaboration is a desired goal, I explore the reasons why collaboration occurs or is thought to be important in CRS policymaking. Again, I identify several examples of knowledge voids that potentially influence policy perceptions leading to conflictive views and relationships in the high-tech world of U.S. CRS. Generally, examples of knowledge gaps are anecdotal in nature and are what I call "micro knowledge voids." In other words, they are isolated examples of writings and/or statements by those involved in the actual process of CRS policymaking or by those who study and write about that process. Each individual example might not overly affect perceptions and the CRS policymaking process in its totality, but this dissertation posits that such examples demonstrate a pattern of insufficient knowledge concerning the highly esoteric and complex subject matter of CRS in the political arena and that such patterns are symptomatic of the larger problem of divergent and conflictive policy perspectives. Attempting to craft laws, policies, and regulations for a complex technological system such as space-based remote sensing in an environment devoid of deep understanding of the policy issues and how they affect the overall viability of an important segment of the U.S. economy (e.g., the satellite component of geospatial information) can be highly problematic.

Finally, in Chapter 4, I critically assess U.S. CRS policymaking efforts from 1984 to the present, while analyzing the perceptions and actions of government and industry. I also focus in more detail on the knowledge void phenomenon in CRS policymaking and related activities and tie the micro-knowledge voids to a structural or macro phenomenon. There, I explicate the notion of a connection between knowledge voids and divergent policy perceptions, potentially leading to flawed policy decisions. Of course, the phenomenon is not just limited to the politics of CRS; instead, it has ramifications for many fields of STS. The chapter expands on my notion that CRS knowledge voids contribute to CRS perception gaps and ultimately to CRS policy conflicts. Conversely, I suggest that enhanced knowledge of remote sensing policy issues can lead to unified perceptions (or at least less divergent perceptions) and ultimately to an environment of collaboration on policy issues.

Obviously, the order can also work in reverse. For example, an environment of collaboration can often lead to a merging of perceptions, and during the process, a potential increase in knowledge through knowledge sharing. On the other hand, an environment in which policy clashes occur can lead to a greater widening of perspectives, often resulting in a polarization of policy stances. Of course, it is important to understand that other factors also influence perceptions and perception gaps, such as interests, institutional and organizational cultures, agency missions, and world views, etc. Such factors have been widely studied and explicated in the existing STS literature (e.g., "Interest Theory" in the Sociology of Scientific Knowledge wing of STS). In other words, my hypothesis does not limit divergent perceptions to just the potential influences of knowledge voids. Nevertheless, my research led me to the conclusion that the politics of CRS can be characterized as policy outcomes affected by knowledge voids, perception gaps, and conflicts and/or collaboration. On a commonsensical level, it seems difficult to image that collaboration can easily exist when policy perceptions are highly conflictive and sometimes even diametrically opposed. Chapter 4 and Appendix F through H provide concrete examples of how this phenomenon operates.

A significant portion of Chapter 4 is devoted to a discussion of a phenomenon that I term "macro knowledge voids." Macro knowledge voids are major gaps in awareness and are structural or broad in nature. Instead of individual instances of not knowing specific facts associated with CRS and related policy issues, general knowledge voids on the subject include such areas as unfamiliarity with foreign CRS systems, laws, and policies; underestimating the difficulty of correctly interpreting CRS imagery and reporting on such in the media or in government and non-governmental forums; and even the reasons why several U.S. CRS license applicants have yet to develop and operate CRS systems.[138] NOAA's ACCRES brought up the issue of CRS license applicants not following through on their approved licenses for significant periods of time, terming such unused licenses "paper licenses."[139] Thus, Chapter 4 attempts to fill this major knowledge void by determining and analyzing the root causes of U.S. CRS license applicants' inability to develop, launch, and operate CRS satellites. Is it because of financial problems or factors related to foreign competition for CRS systems? These are important issues or questions for U.S. CRS regulators and policymakers in attempting to foster and grow a viable U.S. CRS industry.

Finally, in the concluding section of Chapter 4, recommendations are offered on how to bridge knowledge and perception gaps that effect the current laws, policies, and regulations for promoting while simultaneously controlling U.S. CRS activities. Future directions for STS research in this fascinating area of technology are also proposed. In doing so, it is hoped that the effort expended on researching and writing this dissertation proves fruitful and will fill some of the knowledge voids concerning the politics of U.S. CRS. It has definitely filled many of my own knowledge voids that preceded my research efforts for this dissertation.

Notes

1. Joanne I. Gabrynowicz, "The Promise and Problems of the Land Remote Sensing Policy Act of 1992," *Space Policy*, Vol. 9, No. 4 (November 1993), 328.

2. Lawrence W. Fritz, "High Resolution Commercial Remote Sensing Satellites and Spatial Information Systems," *ISPRS Highlights*, Vol. 4, No. 2 (June 1999); http://www.isprs.org/publications/highlights/highlights0402/fritz.html, accessed May 21, 2006. Also, see Anthony R. Curtis, ed. *Space Satellite Handbook*, 3rd Ed. (Houston, TX: Gulf Publishing Co., 1994), 4. For technical details see NASA, "Explorer-6," April 6, 2005; http://nssdc.gsfc.nasa.gov/database/MasterCatalog?sc=1959-004A, accessed May 27, 2006.

3. National Oceanic and Atmospheric Administration, "April 1, 1960 – TIIROS;" http://noaasis.noaa.gov/NOAASIS/ml/40yearsa.html, accessed May 14, 2006.

4. See Curtis, 4. Although Explorer-6 was the first remote sensing satellite to photograph the earth from space, TIROS-1 has been incorrectly described as the first remote sensing satellite. For details on Explorer-6 see Ram Jakhu, "International Law Governing the Acquisition and Dissemination of Satellite Imagery," in James F. Keeley and Robert N. Huebert, eds., *Commercial Satellite Imagery and United Nationals Peacekeeping: A View From Above* (Aldershot, Hampshire, England: Ashgate, 2004), 12. In his chapter in this book, Jakhu wrote, "since the launch of the first remote sensing satellite in 1960" (which would have been TIROS). As mentioned at the outset of this chapter, the first Earth-orbiting remote sensing satellite that provided a photo of the Earth from space was NASA's Explorer-6, launched on August 7, 1959.

5. See Thomas P. Hughes, *Networks of Power: Electrification in Western Society,* 1880-1930, 3rd Ed. (Baltimore, MD: Johns Hopkins Press, 1993).

6. To grasp the power and relationships between humans (actors) and non-human entities (actants), see Bruno Latour, *Science in Action* (Cambridge, MA: Harvard University Press, 1987).

7. See Donald MacKenzie, *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance* (Cambridge, MA: MIT Press, 1990).

8. Ibid,

9. Donna J. Haraway, *Simians, Cyborgs, and Women: The Reinvention of Nature* (NY: Routledge, 1991), 189.

10. Mark Elam, "Spyglass On The World: The Culture and Politics of Remote Sensing," draft paper presented at the Cultural Politics of Technology Workshop, Trondeim, Norway, Centre for Technology and Society, Norwegian University of Technology and Science, June 15-16, 1998, 6; http://www.ntnu.no/sts/content/Papers/Spyglass.html, accessed May 13, 2005.

11. Richard G. Johnson, "Supporting the Dayton Peace Talks," in Baker, O'Connell and

Williamson, eds., *Commercial Observation Satellites: At the Leading Edge of Global Transparency* (Santa Monica, CA and Bethesda, MD: RAND and the American Society for Photogrammetry and Remote Sensing, 2001), 299, 302.

12. Vipin Gupta and Adam Bernstein, "Keeping an Eye on the Island: Cooperative Remote Monitoring in the South China Sea," in Baker, O'Connell and Williamson, 341-345 and 353-354. .

13. Einar Bjorgo, "Supporting Humanitarian Relief Operations," in Baker, O'Connell, and Williamson, 408-422.

14. Andrew MacInnes, panelist comments in Thompson, Ken, rapporteur, *Proceedings • Commercial Remote Sensing Satellite Symposium* (September 13`15, 2006), edited by Judith Carrodeguas, Dan Stillman, Ken Thompson, and Kay Weston, Institute for Global Environmental Strategies, 2006; http://www.crssymposium.com/program/CRSSymposiumProceedings.pdf, accessed January 6, 2007.

15. _____, "ASPRS Industry News," *Photogrammetric Engineering and Remote Sensing* (*PE&RS*), Vol. 70, No. 12 (December 2004), 1342.

16. Rajesh Paul, Siva Subramanian and Shalabh Bharadwaj, "Creation of Digital City Model using Single High Resolution Satellite Imagery," *PE&RS*, Vol. 72, No. 4 (April 2006), 341-342.

17. Gabrynowicz, "The Promise and Problems of the Land Remote Sensing Policy Act of 1992," 328.

18. See MacKenzie, *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance*. Key actors in this case study are technologists (engineers), military officials, and politicians/bureaucrats.

19. Gabrynowicz, videotaped lectures on course entitled Space Studies 575: Remote Sensing Policy & Law, Grand Forks, ND: University of North Dakota, Spring 2001.

10. Telephone conversation on October 5, 2004 with Chuck Herring, DigitalGlobe, Longmont, Colorado.

21. Office of Technology Assessment, *UNISPACE '82: A Context for International Cooperation and Competition, A Technical Manual* (Washington, DC: U.S. Government Printing Office, March 1983), 7-8.

22. For articles and discourse on astropolitics, see journal entitled *Astropoltics: The International Journal of Space Politics and Policy*, published by Taylor and Francis, Inc., Philadelphia, PA.

23. Gabrynowicz, taped lectures.

24. For use of remote sensing imagery in the Spratleys, see Gupta and Bernstein, 327-360; for use of remote sensing imagery in the Ecuador-Peru border conflict, see John Gates and John Weikel, “Imagery and Mapping Support to the Ecuador-Peru Peace Process,” in Baker, O’Connell, and Williamson, 311-326; and for use of remote sensing imagery in Kosovo, see Johnson, 297-310.

25. See Edward Luttwak, “From Geopolitics to Geo-Economics: Logic of Conflict, Grammar of Commerce,” *The National Interest* (Summer 1990), 17-23), and Gearóid Ó Tuathail (Gerald Toal), At the End of Geopolitics? Reflections on a Plural Problem at the Century’s End (paper), Blacksburg, VA: Virginia Polytechnic Institute and State University, 1996; http://www.nvc.vt.edu/toalg/Website/Publish/papers/End.htm, accessed December 8, 2007.

26. Roger Jung-ho Kim (President and CEO of a South Korean geospatial firm, KAI Image) statement (September 15, 2996) recorded by Ken Thompson, rappateur, during the Commercial Remote Sensing Satellite Symposium, September 13-15, 2006 held in Washington, DC.

27. For Ikonos imagery of Brazilian deforestation activities, see Solcomhouse.com, “NASA Rainforest Deforestation Images:” http://www.solcomhouse.com/NASArainforest.htm, accessed December 8, 2007.

28. Charles Mondello, George F. Herpner, and Ray A. Williamson, 10-Year Industry Forecast, Phase I-III – Study Documentation, Bethesda, MD: ASPRS, 12.

29. Ibid.

30. MacKenzie, 412.

31. Ibid.

32. See Thomas F. Gieryn, “Boundaries of Science,” in Sheila Jasanoff, Gerald E. Jarkle, James C. Petersen, and Trevor Pinch, eds. *Handbook of Science and Technology Studies* (Thousand Oaks, CA: Sage Publications, 1994), 393-443. Also see Sheila Jasanoff, *The Fifth Branch: Science Advisers as Policymakers* (Cambridge, MA: Harvard University Press, 1990.

33. Rob Kitchin, *Cyberspace: The World in the Wires* (NY: John Wiley & Sons, 2000), 100.

34. Ibid, 124-125.

35. Ibid.

36. Ann M. Florini and Yahya A. Dehqanzada. “No More Secrets? Policy implications of Commercial Remote Sensing Satellites.” (Working Paper No. 1 for the Global Policy Program: Project on Transparency), July 1999;

http://www.ceip.org/files/projects/tcs/remotsensingconf/NoMoreSecrets1.htm, accessed June 3, 2006.

37. Although Orbview-2 (Seastar) also produced imagery for the commercial fishing industry, that sector only accounted for very small percentage of Orbimage's overall imagery sales. The bulk of Orbview-2 imagery distribution went to NASA's SeaWiFS ocean research program.

38. Gabrynowicz, videotaped lectures.

39. Ray A. Williamson, "Remote Sensing Policy and the Development of Commercial Remote Sensing, in Baker, O'Connell, and Williamson, 43.

40. White House, Presidential Directive/NSC-54, Washington, DC, November 16, 1979, 2.

41. Ibid.

42. Ray A. Williamson, "Remote Sensing Policy and the Development of Commercial Remote Sensing," in Baker, O'Connell and Williamson, 41.

43. Ibid.

44. National Aeronautics and Space Administration, "Landsat Program Chronology;" http://geo.arc.nasa.gov/sge/landsat/lpchron.html, accessed July 1, 2006.

45. Ibid.

45. Land Remote Sensing Commercialization Act of 1984 (P.L. 98-365), July 17, 1984.

47. Ibid.

48. Ibid.

49. Ibid.

50. Ibid.

51. Kevin O'Connell, et. al., *U.S. Commercial Remote Sensing Satellite Industry: An Analysis of Risks* (Santa Monica, CA: RAND, 2001), xi, 2, 65. Also see Colleen Hanley, "Regulating Commercial Remote Sensing Satellites Over Israel: A Black Hole in the Open Skies Doctrine," *Administrative Law Review*, (no date, online version), Washington, DC: American University, 1; http://www.wcl.amercian.edu/journal/alr/52/52-1hanley.pdf?rd=1, accessed July 1, 2006. In addition, see Timothy Stryker, comments in Advisory Committee on Commercial Remote Sensing (ACCRES), National Oceanic and Atmospheric Administration (NOAA), Summary of Meeting [1st Meeting], September 30, 2002, 3; http://www.accres.noaa.gov/accres_meeting_report.pdf, accessed September 14, 2007.

52. Kevin M. O'Connell and Gregory Hilgenberg, "U.S. Remote Sensing Programs, and Policies," in Baker, O'Connell and Williamson, 156.

53. Williamson, 37.

54. Between January 1993 and September 1994 (less than two years since the passage of the Land Remote Sensing Policy Act of 1992), six license applications were submitted to NOAA for future operation of CRS satellites. Those applications came from EarthWatch (now DigitalGlobe), EOSAT, Space Imaging, and Orbimage (the latter two now GeoEye), according to O'Connell and Hilgenberg.

55. Kevin O'Connell and Beth Lackman correctly point back to the 1984 Land Remote Sensing Commercialization Act as the foundation for U.S. CRS and they discount the perceptions of many CRS observers that the 1994 PDD-23 was the decisive document that launched U.S. CRS activities. To them, PDD-23 was simply one of the many important milestones in the political history of U.S. CRS. See Kevin O'Connell and Beth E. Lachman, "From Space Imagery to Information: Commercial Remote Sensing Market Factors and Trends," in Baker, O'Connell and Williamson, 56.

56. Williamson, "Remote Sensing Policy and the Development of Commercial Remote Sensing," 43.

57. Donald T. Lauer, An Evaluation of National Policies Governing the United States Civilian Satellite Land Remote Sensing Program, Ph.D. dissertation, Santa Barbara, CA: University of California at Santa Barbara, 1990, 8.

58. Ibid, 9.

59. Ibid.

60. Ibid, 66.

61. Ibid.

62. Williamson, 43. Also see Lauer, 68.

63. Wim Baker, "The Indian Remote Sensing satellites," *EARSeL Newsletter* (June 1998); http://www.itc.nl/~bakker/earsel/9806b.html, accessed June 3, 2006.

64. Five-meter resolution imagery was achieved by the film-based KFA-1000 cameras aboard Russian Resurs-F1 satellites. Two-meter resolution imagery was produced by the KVR-1000 optical scanner aboard Russian Kometa satellites. For additional information of this subject, see George J. Tahu, "Russian Remote Sensing Programs and Policies," in Baker, O'Connell and Williamson, 166-167.

65. White House, Presidential Directive on National Space Policy, Washington, DC,

February 11, 1988; http://www.fas.org/spp/military/docops/national/nspd1.htm, accessed 20 June 20, 2006.

66. Williamson, 41. The DOC-commissioned studies were: ECON, Inc., Commercialization of the Land Remote Sensing Satellite System (Landsat), DOC Contract No. NA-93-SAC-00658, April 1, 1983; Earth Satellite Corporation and Abt Associates, Inc., A Study to Examine the Mechanisms to Carry Out the Transfer of Civil Remote Sensing Systems to the Private Sector, DOC Contract No. NA-83-SAC-00679, March 28, 1983; and National Academy of Public Administration, Space Remote Sensing and the Private Sector: An Essay, DOC Contract No. NA-93-SAC-066, March 1983.

67. Ann M. Florini and Yaya A. Dehqanzada, “No More Secrets? Policy Implications of Commercial Remote Sensing Satellites,” (Carnegie Paper No. 1); Washington, DC, July 1, 1999; http://www.carnegieendowment.org/publications/index.cfm?fa=print&id=150

68. Ibid. Also see David P. Radzanowski, *CRS Report to Congress: The Future of Land Remote Sensing Satellite System (Landsat)*, Washington, DC: Congressional Research Service, September 16, 1991.

69. Florini and Dehqanzada (supra note 53).

70. Office of Technology Assessment, *Remote Sensing and the Private Sector: Issue for Discussion – A Technical Memorandum*, OTA-TM-ISC-20 (Washington, DC: U.S. Government Printing Office, March 1984), 7.

71. Ibid, iii.

72. White House, Presidential Directive on National Space Policy, Washington, DC, February 11, 1988; http://www.fas.org/spp/military/docops/national/nspd1.htm, accessed 20 June 20, 2006.

73. White House, National Space Policy Directives and Executive Charter, NSPD-1, Washington, DC, November 2, 1989; http://www.au.af.mil/au/awc/awcgate/nspd1.htm, accessed June 3, 2006.

74. Ibid.

75. Ibid.

76. Ibid.

77. White House, U.S. Commercial Space Policy Guidelines, NSPD-3, Washington, DC, February 11, 1991; http://www.au.af.mil/au/awc/awcgate/nspd3.htm, accessed June 20, 2006.

78. Williamson, 50.

79. A bill to enact that law was introduced in Congress in 1991.

80. U.S. House of Representatives; Committee on Science, Space, and Technology, Subcommittee on Environment, *The Landsat Program Management Plan and H.R. 3614, National Land Remote-Sensing Policy Act of 1991*, (hearings), 102nd Congress, 2nd Session (Washington, DC: U.S. Government Printing Office, 1992), 57.

81. Al Gore, comments in U.S. Senate, Committee on Commerce, Science, and Technology; Subcommittee on Science, Technology and Space, *S. 2297, The Land Remote Sensing Policy Act of 1992* (hearings), 102nd Congress (Washington, DC: U.S. Government Printing Office, 1992), 1.

82. Ernest F. Hollings, comments in U.S. Senate, Committee on Commerce, Science, and Technology; Subcommittee on Science, Technology and Space, *S. 2297, The Land Remote Sensing Policy Act of 1992*, 3.

83. See "Policy Milestones" section in Courtney A. Stadd and Ronald J. Birk, "No Strings Attached? Commercial remote sensing companies hope that US government policy will keep pace with the industry's rapidly expanding needs," *Imaging Notes* (July-August 1999); http://www.imagingnotes.com/julaug99/ja99nost.htm, accessed September 12, 2004. Also see Michael Belligan, "Mixed Signals: A History of the Landsat Program and U.S. Commercial Remote Sensing Industry," (unpublished paper), Fall 2004; http://www.msu.edu/~belligal/GEO801_LANDSAT.htm, accessed May 27, 2006. For correct acknowledgement of the original regulatory foundation in 1984, see the "Commercial remote sensing emerges" section in Florini and Dequanzada ,"Commercial Satellite Imagery Comes of Age," *Issues in Science and Technology online* (Fall 1999);" http://www.issues.org/16.1/florinia.htm, accessed June 13, 2004.

84. Department of Commerce, National Oceanic and Atmospheric Administration, "Licensing of Private Land Remote Sensing Space Systems; Interim First Rule (15 CFR Part 960)," *Federal Register*, Part IV, Vol. 65, No. 147 (July 31, 2000), 46822.

85. Ibid.

86. Land Remote Sensing Policy Act of 1992 (P.L. 102-55), October 28, 1992.

87. Laurel L. Wilkening, statement in U.S. Congress, House of Representatives, Committee on Science, Subcommittee on Space, *The Future of the U.S. Space Industrial Base* (hearings), 103rd Congress, First Session (Washington, DC: U.S. Government Printing Office, 1993), 12.

88. Jerald S. Howe, Jr. "U.S. Space Industrial Competitiveness: Legal and Regulatory Issues," in U.S. Congress, House of Representatives, Committee on Science, Space and Technology, Subcommittee on Space, *The Future of the U.S. Space Industrial Base* (hearings), 192. .

89. ______, "Quickbird-2; http://directory.eoportal.org/pres_QUICKBIRD2.html, accessed

June 11, 2006. Often called QuickBird-2 in the CRS literature, DigitalGlobe prefers to just call is second QuickBird satellite, “QuickBird,” without the “-2” designation.

90. Sven Grahn, “The Quickbird-1 Launch Failure;” http://www.svengrahn.pp.se/histind/Quickbird/Quickbird.html, accessed June 11, 2006.

91. Orbital Sciences Corporation, “Orbview-3;” http://www.orbital.com/SatellitesSpace/LEO/OV3/, accessed June 11, 2006.

92. ______, “Orbview;” http://www.astronautix.com/craft/orbview.htm, accessed June 11, 2006.

93. Jason Bates, “Orbimage Reaches Deal to Emerge From Bankruptcy,” *Space News*, February 3, 2003; http://www.space.com/spacenews/archive03/orbimagearch_020303.htm, accessed September 1, 2007.

94. See O’Connell, et. al.

95. O’Connell, et. al., 100. Of note, Space Imaging (then part of Lockheed Martin) received a license on April 22, 1994 for its 1-meter Ikonos satellites, Orbimage (then part of Orbital Sciences Corp.) received its license for its 1-meter Orbview-3 and –4 satellites on May 5, 1994, and DigitalGlobe (then called WorldView Imaging Corp.) received its license on September 2, 1994 for its QuickBird satellites. WorldView Imaging Corp. was formed in 992, but merged with Ball Aerospace and Technologies Corp. in March 1995 to become EarthWatch. It later changed its name to DigitalGlobe to represent its new image and mission of not just watching the earth but also processing and marketing digital CRS imagery data.

96. Gerald M. Steinberg, “Commercial Observation Satellites in the Middle East and the Persian Gulf,” in Baker, O’Connell, and Williamson, 235.

97. Ibid.

98. Fritz.

99. Steinberg, 236-237.

100. Commercial Space Act of 1998 (P.L. 105-303), January 27, 1998.

101. Ibid, 20.

102. Memorandum of Understanding Among the Departments of State, Defense, Commerce, Interior and the Intelligence Community Concerning the Licensing of Private Remote Sensing Satellite Systems, Washington, DC: January 4, 2000, 4; http://www.accres.noaa.gov/MOU1-4-200.pdf, accessed June 17, 2006. Also, for a slightly different version of the MOU with a different title but essentially containing the same language after the header section, see White House, Office of Science and Technology Policy and the

National Security Council, Fact Sheet Regarding the Memorandum of Understanding Concerning the Licensing of Private Remote Sensing Satellite Systems, Washington, DC, February 2, 2000, 4.

103. Ibid, 2.

104. Department of Commerce, Office of Space Commercialization, "General Policy Issues;" http://www.nesdis.noaa.gov/space/general/, accessed June 11, 2006.

105. White House, Fact Sheet: U.S. Commercial Remote Sensing Space Policy, Washington, DC, April 25, 2003; http://www.whitehouse.gov/news/releases/2003/05/20030513- 8.html, accessed June 11, 2006. Also see Susan Smith, "The Care and Feeding of Commercial High Resolution Imagery Satellite Companies," *GIS Weekly*, (18-22 Oct 2004); http://www.10.giscafe.com/nbc/article/view_weekly.php?newsletter=1&run-/date=25-Oct-2004, accessed June 24, 2006.

106. _____, "Digital Globe Applauds Remote Sensing policy Issued by White House," (press release), Longmont, CO: DigitalGlobe, May 13, 2003; http://media.digitalglobe.com/index.php?s=press_release_popup&item=25, accessed June 11, 2006.

107. Dennis Jones, "Commercial Remote Sensing and National Security," *Crosslink*, Vol. 5, No. 2 (2004); http://www.aero.org/publications/crosslink/summer2004/09.html, accessed June 7, 2006.

108. Ibid.

109. _____, "Contracts. National Imagery and mapping Agency –Correction," (press release number 026-03), Washington, DC: U.S. Department of Defense, January 17, 2003; http://www.defenselink.mil/contracts/2003/c01172003_ct026-03.html, accessed June 25, 2006.

110. Ibid.

111. Frank Sietzen, Jr., "A Clearview of NIMA's Commercial Imagery Use," *Geospatial Solutions* (March 1, 2003); http://www.geospatial-online.com/article/articleDetail.jsp?id=48147, accessed June 24, 2006.

112. DigitalGlobe, "DigitalGlobe Awarded in Excess of $500 Million NextView Contract;" (press release) September 30, 2003; http://media.digitalglobe.com/index.php?s=press_release_popup&item=11, accessed June 11, 2006.

113. Scottie Barnes, "NGA Awards NextView Second Vendor Agreement," *Geospatial Solutions* (October 1, 2004); http://www.geospatial-online.com/geospatialsolutions/article/articleDetail.jsp?id=125948, accessed June 11, 2006.

114. ACCRES began holding meetings on September 30, 2002. Usually, the meetings consist of two sessions (a closed session and a public session), but the entire first meeting was open to the public. Robert Winokur of Earth Satellite Corporation chaired the first four Committee meetings (2002-2003).

115. Advisory Committee on Commercial Remote Sensing (ACCRES), National Oceanic and Atmospheric Administration (NOAA), "U.S. Department of Commerce Charter of the Advisory Committee on Commercial Remote Sensing, May 3, 2004, 1;" http://www.accres.noaa.gov/ACCRESCharter5504.pdf, accessed June 17, 2006.

116. Ibid, 5.

117. William Stoney, "Foreign Land Imaging Satellite Programs," in Advisory Committee for Commercial Remote Sensing (ACCRES), National Oceanic and Atmospheric Administration (NOAA), Meeting Summary [2nd Meeting], January 14, 2003, 5; http://www.accress.noaa.gov/Draft-Meeting-Minutes.doc, accessed September 14, 2007.

118. Kay Weston, comments in Advisory Committee for Commercial Remote Sensing (ACCRES), National Oceanic and Atmospheric Administration (NOAA), Open Session Meeting Summary [7th Meeting], September 13, 2005, 3; http://www.accres.noaa.gov/7thMeeting09-13-05.pdf, accessed September 13, 2007. Also see Stryker, comments in Advisory Committee on Commercial Remote Sensing (ACCRES), National Oceanic and Atmospheric Administration (NOAA), Open Session Meeting Summary [5th Meeting], August, 27, 2004, 4; http://www.accres.noaa.gov/Final9-16-04.pdf, accessed September 13, 2007. For the final report, see Michel Andrieu, et. al., *Space 2030: Tackling Society's Challenges* (Paris, France: OECD, 2005).

119. Weston. For the international marketing report, see Global Marketing Insights, Inc., Survey and Analysis of Remote Sensing Market, Aerial and Spaceborne, September 2005; http://www.licensing.noaa.gov/Survey/Analysis,pdf, accessed September 9, 2007.

120. See Weibe E. Bijker, Thomas P. Hughes, and Trevor J. Pinch, eds., *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (Cambridge, MA: The MIT Press, 1999).

121. Lauer, 5.

122. Radzanowski, 3. Aside for its military utility (e.g., use of Landsat imagery for mapmaking and broad-area terrain analysis during the Gulf War in 1991), the "public good" aspects of Landsat imagery include global environmental monitoring, land-use research, crop-yield forecasting, wildlife management, and other applications beneficial to the forestry, mining, and fishing industries. Presently, the Group on Earth Observations (GEO) lists the following nine societal benefits of non-military remote sensing: 1) disaster mitigation and recovery, 2) environmental research and monitoring, 3) energy resource management, 4) climate research, 5) water resource management, 6) weather monitoring and forecasting, 7) terrestrial, coastal, and marine ecosystem management, 8) agricultural support, and 9) biodiversity research and

conservation. For details on these applications, see _____, “About GEO; http://www.earthobservations.org/about/about_GEO.html, accessed January 19, 2007.

123. Ibid.

124. Lauer, 55. Also see White House, Presidential Directive/NSC-4, Washington, DC: October 10, 1978, 4.

125. Williamson, in Baker, O’Connell, and Williamson, 40-41.

126. Lauer, 68.

127. James H. Scheuer, statement, U.S. House of Representatives; Committee on Science, Space, and Technology; Subcommittee on Environment, *The Landsat Program Management plan and H.R. 3614, National Land Remote-Sensing Policy Act of 1991* (Washington, DC: U.s. Government Printing Office, April 7, 1991), 55.

128. Radzanowski, 5.

129. Kevin M. O’Connell, et. al., xi.

130. See Scott Pace, *Merchants and Guardians: Balancing U.S. Commercial Interests in Space Commerce*, RP-787 (Santa Monica, CA: RAND, 1999).

131. See Pamela E. Mack, *Viewing the Earth: The Social Construction of the Landsat Satellite System* (Cambridge, MA: The MIT Press, 1990).

132. See Lauer.

133. Ibid, 167.

134. Ibid.

135. See Baker, O’Connell and Williamson.

136. See Keeley and Huebert.

137. See Kevin M. O’Connell, et. al.

138. Analysis of the problem of CRS licensees not succeeding to develop or launch CRS systems was prompted by comments made by Dr. Timothy Luke of Virginia Tech during a scoping session for establishment of a science and technology policy institute. At an April 7, 2006 meeting in Blacksburg, Virginia, Dr. Luke suggested that a study to determine the causes of failures of several policy institutes might be a fruitful and informative endeavor

139. Doug Hall, comments in Advisory Committee for Commercial Remote Sensing (ACCRES), National Oceanic and Atmospheric Administration (NOAA), Open Session Meeting Summary [7th Meeting], 4.

Chapter 2

Technology/Policy Issues: Competing Viewpoints

Introduction

This chapter examines the contentious issues and divergent viewpoints that impact efforts to understand and craft laws, policies, and regulations controlling the high-tech world of U.S. CRS. Knowledge and assessments of these issues and perspectives are key to formulating and implementing effective CRS programs and policy regimes. First, I begin with a brief survey of similar technologies and technological studies as a subset of STS – largely relying on the SCOT framework of Donald MacKenzie, but also reflecting the conceptual foundations laid out in previous research on civil remote sensing programs by Donald Lauer and Pamela Mark. Since CRS is a complicated and provocative technology due to its inherent dual-use features (i.e., civil/commercial/scientific applications on the one hand and military uses on the other hand), it is surrounded by numerous political issues and perspectives on how the technology should be used and controlled. As this chapter demonstrates, the most significant and contentious issues are those related to national security, ideals of openness and transparency, image resolution and shutter control, competition in the global marketplace, and the economic and scientific benefits of CRS.

My intent in the ensuing sections of this chapter is to provide insights into why CRS policymaking is such a divisive and contentious technology and why there are such widely competing viewpoints on how it should be controlled and regulated. I also introduce several examples of knowledge voids and postulate that such voids can influence competing opinions and viewpoints on CRS operations and policies. As demonstrated in this chapter, national security perspectives vs. ideals of openness and global transparency are the paramount issues affecting USG's attempts to legislate and control CRS activities and thus will be covered in the early parts of the chapter. These issues set the stage and directly affect all other issues covered in the remaining parts of the chapter. My intent here is to present examples of how national security advocates often fail to perceive or appreciate the economic and scientific benefits provided by CRS as an adjunct to civil remote sensing and how and why it is difficult for them to equate national security with, or consider it as a component of, the broader concepts of social, political, and economic wellbeing. Essentially, CRS-related policy conflicts comprise a spectrum between narrow thinking and unconstrained broader visions.

Each of the various issues identified and developed in the ensuring sections and subsections are used to identify and analyze various knowledge deficiencies that affect the U.S. CRS industry and USG perspectives on mechanisms for controlling CRS activities. The knowledge gaps are generally anecdotal in nature, but are identified and analyzed as such to set the conceptual stage for viewing and understanding this phenomenon (knowledge voids) as a structural impediment to informed and efficacious CRS policymaking, which is further explicated in Chapter 4.

Following the national security aspects of CRS, this chapter details numerous examples of policy perspectives driven by the ideals of information openness and transparency – often the converse of national security viewpoints and often acting to polarize stakeholders in the policymaking arena of U.S. CRS technology. Next, CRS spatial resolution and sensor operational controls (aka, shutter controls) are introduced and discussed to determine how they give rise to policy conflicts and associated knowledge voids. Following that, I discuss issues concerning U.S. CRS competitiveness in the global marketplace. This aspect of CRS and its ramification for U.S. policymaking/rulemaking is where a plethora of knowledge gaps and misconceptions can be identified and analyzed. The chapter then continues with a section on scientific applications and the role that scientists play in CRS policymaking. The section also includes a discussion of foreign CRS satellite systems and programs, a field that seems to be little understood by the USG and the U.S. CRS industry alike, outside of a few dedicated individuals and scholars who study this highly complicated and esoteric aspect of CRS. There, I portray competing viewpoints associated with scientific applications driven by knowledge (or lack thereof) of the capabilities of CRS imaging systems in supporting scientific research (e.g., land use and environmental monitoring, etc.). Various policy perspectives are identified and analyzed in the cultural and institutional environments of industry, government, and the scientific community.

The final section addresses market issues and foreign competition as problems for the U.S. CRS industry and its USG regulators and characterizes these issues as highly complex, yet important factors in CRS policymaking. It was included in this dissertation for two reasons: one, to describe the immense complexity of and daunting challenges in comprehending what other nations are doing in the CRS arena (and how those CRS activities pose market competitiveness concerns for the U.S. CRS industry), and, two, to use this dimension of CRS economics to show how knowledge voids are easily formed or are already extant due to the rapid multinational advances in remote sensing technology and the apparent inability of current U.S. CRS policies and regulations to stem the global tide of CRS satellites that could render U.S. CRS laws and policies counterproductive.

After reviewing and analyzing many of the key issues and perspectives and several exemplary knowledge gaps related to CRS policymaking, this chapter concludes with an analytical summary of my research findings focused on competing viewpoints on how CRS systems should be designed, promoted, utilized, and regulated. At this point, I invite the reader to embark on an intellectual journey across the political landscape of CRS policymaking strewn with contentious issues, divergent perspectives, and knowledge chasms.

Conceptual Patterns: Parallels in STS Works

The remote sensing genie is out of the bottle, and both positive and negative consequences for commercial and national security space activities may result.

– Frank Sietzen, Jr., September (2001)[1]

CRS is a very powerful, esoteric, and complicated field of technology. Donald MacKenzie studied a similarly complicated and esoteric technology – nuclear missile guidance systems.[2]

The main focus of his monumental work was on the complex, conflictive interactions between different social groups – technological, military, and political – involved in the development and use of ballistic missile guidance systems. U.S. commercial remote sensing involves an even more extensive array of social actors. MacKenzie focused on the technology of missile guidance as a window through which to understand "nuclear thinking."[3] Similarly, this study focuses on the political and socio-economic aspects of space-based remote sensing as a way to comprehend and evaluate how relevant groups and actors think about earth observation and global surveillance and how it should be developed, used, and controlled.

CRS laws and regulations are an outgrowth of policies that governed civilian remote sensing systems (particularly, the Landsat systems) in years past. Issues of openness and global transparency vs. national security concerns affected space-based remote sensing policymaking in the pre-CRS era of the 1970s and 1980s. These issues and challenges were substantially covered and analyzed by Donald Lauer and Pamela Mack, who studied and wrote about the political dynamics of the Landsat program and attempts by the USG to commercialize that program. This chapter adds to the literature and knowledge base on remote sensing by also focusing on the CRS era of the 1990s and beyond. Using the MacKenzie model of studying technological development, and by extension, the policies that affect its utilization, I focus on relevant heterogeneous groups in this area (i.e., CRS firms, politicians and bureaucrats, scientists, and various other users of CRS imagery, etc.), their perspectives on issues created by the technology and utilization of CRS, and how policies and regulations are the product of conflicts and collaboration over such issues. MacKenzie's study of the politics of nuclear missile guidance delved into what he called a "complex process of conflict and collaboration between a range of social actors …"[4] Similarly, I introduce and analyze how technology and society intersect within the CRS policymaking process and social actors' views on various CRS issues affect that process. As MacKenzie argued, "technological development [and I posit, technology utilization and control] cannot satisfactorily be treated in isolation from organizational, political, and economic matters."[5] In reaching this conclusion, MacKenzie relied heavily on another STS giant, Thomas Hughes, who developed the "large technological systems" approach to understanding complex technical systems that included human and non-human factors and dimensions.[6] Extrapolating from Hughes's notion, I also consider the socio-political, economic, and technical aspects of CRS and how they impact the CRS policymaking process. I also examine how knowledge voids affect CRS policies, particularly deficient policies (which could be characterized as "reverse salients" in Hughesian terms)[7] intent on simultaneously promoting and regulating the CSR industry. This is done within the context of conflict and collaboration over issues such as national security, openness/global transparency, shutter control regimes, foreign competitiveness factors, and the scientific and economic utility of CRS. In doing so, I create an intellectual environment for future discourse on understanding knowledge voids and whether or how they affect the policymaking process for CRS and similar technologies. I also argue that knowledge gaps concerning the multidimensional aspects of CRS can widen the gulf of existing interests among USG and industry actors, making it difficult to achieve effective, business-friendly CRS policies. This chapter also expands on MacKenzie's notion of heterogeneous groups and their knowledge voids.

Competing and contentious policy perspectives on the aforementioned issues have evoked and still give rise to conflict and collaboration over policy formulation and execution in the CRS arena. For example, conflict over policy perspectives was emphasized by Congressman Larry Combest, member of the House Permanent Select Committee on Intelligence, during a February 9, 1994 joint hearing on CRS with the House Committee on Science, Space, and Technology. In his opening statement, Congressman Combest noted, "Both industry and government have strongly held legitimate points of view on these issues [CRS licensing regulations and procedures]. It seems that no likely solution will fully satisfy either side."[8]

Another example of perspectives on CRS policies from both defense and industy experts was captured in a Spring 2003 seminar hosted by the Industrial College of the Armed Forces, at Ft. Mc Nair in Washington, DC. The report of the proceedings of the seminar was critical of current space policies and government-industry relations that affect commercial space operations. Efficient and realistic government policies were seen as key to sustaining the health and future prosperity of the space (and remote sensing) industry. As stated in the report summary, "Continued preeminence in space depends as much on efficient policies as on the sheer scope of monetary investment."[9] Yet, as the following sections demonstrate, several CRS issues have created political conflicts and controversies and concomitant attempts at collaboration to promote the nascent yet burgeoning industry of U.S. CRS. By far the most contentious issue concerning CRS and the policies and regulations that govern its operations is that of the oft-perceived view that CRS technology poses potential risks to U.S. national security. The following section discusses the debates over this issue and how divergent perspective on U.S. CRS have affected the policymaking process.

National Security vs. Openness

The government policymaking process must consider both the competitiveness and national security implications of the dual-purpose technologies associated with imaging satellite systems.

– RAND (2001)[10]

The whole history of U.S. policy toward remote sensing has been one of grappling with two difficult tradeoffs: between protection of national security secrets versus promotion of Open Skies as a means of legitimating satellite reconnaissance and civilian remote sensing, and between establishing a commercial industry versus ensuring the public benefits of this unusually comprehensive, and expensive, source of information.

– Ann Florini & Yahya Dehqanzada (1999)[11]

National Security Perspectives

There are several dimensions to the national security concerns over CSR operations. For example, focusing on the national security aspects of CRS policy issues, Bob Preston, RAND space policy analyst, points out that advanced high-resolution and multi-spectral satellite imagery, if acquired by adversarial forces or groups hostile to the U.S., can threaten military operations by disclosing physical locations of military forces and diluting the advantage of military surprise, or what he terms "information advantage."[12] Given the fact that foreign systems can now provide adversaries with valuable information about their opponents, Preston argued that defense planners need to be cognizant of this fact and plan their missions and operations accordingly.[13] We are now at a point where it is difficult to stop the flow of CRS imagery data and information to potential enemies or adversaries, since such imagery is available from numerous foreign providers.

Security concerns arising from organizational interests actually surfaced during the early period of the Landsat program. For example, in his writings on the relationship between national security and civil remote sensing, Lauer described the ideological and policy conflicts between national security institutions and those who wanted to use Landsat imagery to advance scientific research of the earth's surface. His research showed that, initially, military experts refused to accept civilian remote sensing programs as necessary.[14] This perspective represented a knowledge gap in appreciating the value of remote sensing for non-military purposes, such as environmental monitoring and land resource surveys, or that commercial systems could be of use by the military as a backup to their own spacebased reconnaissance systems. Had those experts been prescient, they would have been able to forecast that the military would extensively use commercial imagery in a major war about a decade later in 1991 (i.e., The Gulf War). On the flip side, some of the concerns of defense and military officials at the time were that Landsat imagery could reveal sensitive military locations to foreign adversaries – a concern that affects policy and regulatory decisions even in the 1990s and post-2000 era for CRS operations.

In the early 1990s, USG regulators drew on their limited pool of knowledge and insights to create novel ways to solve the national security/openness dilemma concerning future CRS operations. According to Preston, a proposed solution to this dilemma by NOAA was to place constraints on spatial resolution on high-resolution remote sensing systems by degrading pixel size in images.[15] This notion prompted regulatory decisions that may have been affected by a technological and policy knowledge gap on the part of NOAA. Again, according to Preston, "If the uniformly degraded spatial resolution and signal level prevents subpixel detection of military materials, they will do the same for civil objects, degrading the opportunity to develop a commercial market."[16] As a subordinate organization within the DOC, NOAA should have known that such a regulatory restraint (i.e., pixel degradation) would potentially damage efforts to commercialize the U.S. remote sensing industry, a stated goal of the USG as reflected in the Land Remote Sensing Policy Act of 1992. NOAA's proposal may also have been based on an ill-informed view of the capabilities of CRS satellite systems. At the state of the science at that time, commercial satellite sensors were not capable of automatically (i.e., without human interpretation) distinguishing between military objects such as tanks and civil objects such as farm trucks.

A review of primary source literature and documents on the national security concerns over operation of U.S. CRS systems led me to conclude that industry generally leans toward openness and transparency perspective on CRS and is often in conflict with national security proponents over CRS policy issues. However, there have been some industry representatives who have openly advocated governmental control over CRS satellite operations, commonly known as "shutter control." For example, in a March 30, 1994 letter responding to questions posed by Congressman George E. Brown, Jr. (D-Calif.), Chairman of the House Committee on Science, Space and Technology, and Congressman Dan Glickman, Chairman, House Permanent Select Committee on Intelligence, following a joint hearing by these two committees on February 9, 1994 on CRS policies, Walter S. Scott, CEO of WorldView Imaging Corporation (which later became EarthWatch, Inc. and finally DigitalGlobe) stated that if he were in the USG he would allow shutter control constraints on CRS licensees and, that, under some conditions, even prohibiting the export of sensitive CRS satellite technology.[17] Apparently, Scott was less concerned about satellite imaging data transfers.

Conversely, certain segments of the U.S. Congress have often been pro-business and ardent backers of U.S. CRS industry and the latter's views on the national security/openness divide. For example, showing concern over potential foreign domination of the remote sensing satellite market, Congress decided to meet the challenge posed by foreign competition in remote sensing technology and activities by passing the Policy Act of 1992, after debate and consideration of the issues of national security vs. the desire to promote the CRS industry. That watershed legislation governing CRS was quickly followed by a 1994 Presidential Decision Directive (PDD-23 – U.S. Policy on Foreign Access to U.S. Remote Sensing Capabilities), signed on March 9, 1994 and summarized in a White House press release and fact sheet issued on March 10, 1994. The latter addressed national security concerns over foreign access to remote sensing systems and data and enticed commercial firms to enter the remote sensing market. The 1994 Directive attempted to balance national security concerns with desires to foster and promote a vibrant U.S. CRS industry. Yet, PDD-23 (also called NSC-23) was said to have drawn heavy criticism from both industry and its supporters, and from within the USG bureaucracy itself.[18] One such criticism came from the Center for Strategic and International Studies (CSIS), a Washington, DC think tank, which viewed PDD-23 as doing little to "preserve U.S. remote sensing satellite industrial capabilities.[19] Another such criticism of PDD-23 was made by Kevin O'Connell and Beth Lachman, who argued that PDD-23 only defined a broad vision, did little to provide implementing guidance, and that CRS policy was being "crafted on an ad hoc basis."[20] Although the entire PDD is classified and thus not available for analysis by the general public, a policy fact sheet issued by the White House in 1994 seems to confirm this criticism.

According to the fact sheet on PDD-23, the USG's policy goal for civil and commercial remote sensing was "to support and to enhance U.S. industrial competitiveness in the field of remote sensing space capabilities while at the same time protecting US national security and foreign policy interests."[21] Protection of national security was partially covered by the remote sensing technology transfer provisions of PDD-23, as highlighted by the fact sheet, which required USG-to-foreign government agreements for any transfers of remote sensing systems or technical information. Nevertheless, PDD-23 was riddled with provisions that reflected underlying bureaucratic conflicts, including differing goals and agendas of DOS, DOD, and the IC. According to CSIS, the technology nonproliferation provisions of the Directive were included at the insistence of DOS and apparently ignored the concerns of the IC.[22]

The Directive also allowed DOC to assume jurisdiction over international transfer of low-resolution remote sensing satellites (generally considered to be 20 or more meters GSD), previously controlled by DOS and its U.S. Munitions List. According to a CSIS report, DOS fought this move for several years after PDD-23 was issued.[23] Perhaps this demonstrated a knowledge void on the part of DOS, as CSIS pointed out: "It is unlikely that there would have been much of a commercial market for such satellites even if they had been transferred to

Commerce as many other countries can either build imaging satellites of this quality or have access to 30-meter imagery from non-U.S. sources."[24]

The 1992 Policy Act granted licensing authority to DOC, which further delegated this authority to a subordinate office within NOAA (i.e., the National Environmental Satellite Data and Information Service (NESDIS)) to act as the licensing agency for CRS satellites, albeit with consultation and reviews of licensing applications by DOS (for foreign policy issues) and DOD and the IC (for national security issues). Later, NOAA published amended licensing regulations in 2000; this gave the USG powerful control over CSR satellite developments and operations and fueled debates about PDD-23's efficacy and potential for reaching the stated goal of the U.S. to promote a CRS industry.

Being an inherently dual-use technology, CRS creates a political environment for heated debates on both sides of the national security-transparency divide. For example, writing in 1999 on the positive and negative aspects of commercial satellite imagery, Ivan Amato, contributor to MIT's *Technology Review*, pointed out the national security implications of the high-tech world of earth observations, or what he calls the "darker image" perspective.[25] Other examples of the perspective that Amato portrayed are reflected in the pre-2000 debates between Congress and the executive branch and its agencies, prompted by national security concerns. The executive branch (i.e., DOD, DOS, and the IC) generally shared Amato's perspectives on the national security implications of high-resolution commercial satellite imagery, whereas Congress tended to be more supportive of the CRS industry. One of the most alarming scenarios that Amato painted was a terrorist group or rogue nation integrating high-resolution CRS imagery with global positioning system (GPS) data to target key national and civil infrastructures.[26] But what Amato and others with similar concerns or perspectives failed to point out is that GPS receivers and data were already available to any would-be purchaser of high-resolution satellite imagery. Moreover, at the time of Amato's observations, CRS imagery in the 2-meter range was already available from Russian systems and 1-meter imagery was just on the horizon and would become fairly ubiquitous and accessible from several non-U.S. vendors within a decade.

While Amato's perspectives were shared by media representatives and journalists and seemed fairly balanced, such media observations often evoked sharp criticism from CRS industry representatives. Lambasting the *Technology Review* editor John Benditt's note on Amato's piece, John Neer, Vice President of Engineering for Space Imaging, characterized Benditt's perspective on the potential threats posed by commercially available satellite imagery as "luddite-ism" and sharply criticized his knowledge of U.S. policies on CRS technology:

> Unfortunately, the editor, being unfamiliar with the nine-year history [1990-1999] leading to the brink of launching commercial high-resolution satellites [e.g., Space Imaging's Ikonos-2], makes an inappropriate and misdirected suggestion: He suggest the Clinton administration revisit the issue."[27]

Although Neer pointed to PDD-23 as one of the policy documents among others and related legislation (e.g., 1992 Policy Act) that seemingly refuted Benditt's contentions, Neer could also have pointed out Benditt's obvious knowledge gap about PDD-23's provision that allows the USG to direct "shutter controls" on U.S. commercial satellite operators anytime national security concerns are raised. This would have diluted Benditt's observation that, "In the United States, the Clinton administration, leaning toward the interest of the private sector, has established relatively few controls on the role of these once-secret images."[28]

Military perspectives also seemed to mimic Benditt's views on CRS's potential threat to U.S. national security. For example, writing about the military applications of CRS, a U.S. Navy officer with the War Gaming Department of the U.S. Navy War College, Lt. Commander J. Todd Black, opined that the only rational reasons for commercial high-resolution satellite imagery are for targeting and gaining information advantages. Specifically, Black notes: "Otherwise, if traditional land-survey means are available, space based high-resolution imagery does not make sense ."[29] Unfortunately, this view reveals a knowledge void about civilian use of CRS imagery data. Black did not take into account that traditional land-survey methods (likely meaning aerial remote sensing or other ground-based survey/observation techniques) would be difficult if not impossible in foreign nations about which observation data serves more than just military purposes, as will be discussed in detail throughout the remainder of this chapter. Still, this perception is instructive, since it reflects the typical thinking of government officials in DOD, the IC, and DOS.

The U.S. policy goal of fostering an environment for establishment and growth of a U.S. domestic CRS industry while simultaneously ensuring that CRS imagery will not pose a threat national security or the USG's ability to meet its international obligations and maintain beneficial international relations appears incompatible or illogical. How can the U.S. bolster its CRS industry while at the same time restraining and controlling it? Perhaps an analogy of this dichotomous situation might be as follows: One needs to water a tree so that it will grow and create shade, but one also might think that there is a need to cut off its limbs (more than mere pruning) so that they won't fall off and hurt someone. To many critics of U.S. CRS policies and regulations, the USG purports to just prune the CRS tree, whereas they unknowingly or unwittingly wield the power and possible intention to cut off many of its limbs.

Actors outside of the government and industry, but clearly in support of the latter, have insightfully provided this type of critique. For instance, Ann Florini and Yahya Dehqanzada of the Carnegie Endowment for International Peace wrote in 2001 about remote sensing policy conflicts that extended into the international arena. According to their report, a Canadian firm intended to contract with a U.S. satellite manufacturing firm (Orbital Sciences Corporation) to provide the bus (or satellite components housing) for RADARSAT-2, a radar-imaging satellite capable of up to 3-meter GSD resolution.[30] When DOS stalled the process over national security concerns by not expeditiously considering a request to grant Orbital Sciences Corporation a technology export license, the Canadian Government threatened to take its business elsewhere. DOS was not swayed by that threat and its stonewalling led the Canadians to purchase its satellite bus from an Italian firm (Alenia Aerospazio) in January 2000.[31] One wonders if DOS ever considered that a potential tech-transfer project by another willing non-American company could be of equal concern for U.S. national security. Or could it be that the DOS bureaucracy felt that any foreign system components and technology would be vastly different from those offered by American satellite engineers and designers? Perhaps they lacked the sense of urgency to comprehend the situation. Florini and Dehqanzada seem to expound a more realistic perspective:

> In short, the prospects for forging a durable and effective remote sensing control regime seem quite unfavorable. High-resolution satellite technology has already reached virtually every continent in the world. Unlike the United States, which has security interests around the globe and therefore, a strong interest in restricting the proliferation of power-multiplier technologies, other satellite manufactures are likely to find profit motives more compelling. … As technological and cost barriers continue to fall, the likelihood grows dimmer by the day that any single government, or likely consortium of governments, will be able to put meaningful constraints on access to imagery.[32]

Yet, despite the arguments that restricting the free and open enterprise of CRS is futile, the dual-use aspect of CRS has raised, and continues to raise, concerns among U.S. legislators, government bureaucrats, and defense officials over the national security implications of CRS as it operates in the global environment. As noted by Marcia Smith of the Congressional Research Service, "Controversy over the fact that the imagery has military as well as civilian uses continues to complicate this commercial space effort."[33]

Openness and Transparency Perspectives

As democratic norms spread, as civil society grows stronger and more effective in its demands for information around the world, as globalization gives people an ever greater stake in knowing more about what is going on in other parts of the world, and as technology makes more knowledge easier to attain, transparency would appear to be the inevitable wave of the future.

– Ann Forini & Yahya Dehqanzada[34]

The current debate on the national security aspects of commercial remote sensing is raging around one central issue: are we as a nation fundamentally committed to an "open skies" policy, or are we going to adopt the role of policeman of the skies, trying to dictate from month to month who can look at what, depending on the ebb and flow of foreign policy concerns?

– James Frey (Itek Optical Systems), Terry Straeter (GDE Systems), and D. Thompson (Orbital Sciences)[35]

In addition to the USG's desire to promote the U.S. CRS industry, proponents of the concept and principles of information openness characterized by the term "transparency" often counter national security concerns and issues. Those on the transparency side of the openness-national security divide (particularly the CRS industry itself, as well as the media and humanitarian groups) argue that global transparency and security are enhanced by relatively unfettered access to satellite imagery. For example, satellite imagery can aid in treaty monitoring and detecting suspicious weapons proliferation activities, using open-source CRS imagery.[36] Conversely, national security proponents often argue that unrestricted access to CRS imagery by adversarial nations or terrorist groups can threaten U.S. military operations abroad and critical infrastructures (such as nuclear power plants, transportation grids, communications nodes, and key industrial facilities, etc.) at home in the U.S. Of course, such threats depend on the capabilities and intentions of states or groups that threaten U.S. national security and, since much of that is classified, it invariably creates an unavoidable knowledge void for the openness advocates.

Opposing the concerns over national security implications of CRS, openness and transparency advocates argue that civil and commercial remote sensing technology benefits science and other public/economic interests. They also claim that civil and commercial satellite imagery can help resolve international conflicts and disputes and is highly useful in creating transparency in such areas as arms control monitoring, treaty verification, territorial dispute resolutions,[37] detecting natural and man-made disasters, and detecting human rights violations.[38] As RAND policy analysts John Baker and Dana Johnson point out, policy decisions that affect the balance of national security and civil utility/information openness are made in a complicated political, economic, and technological environment.[39] Such an environment requires a high degree of awareness and knowledge concerning these interrelated factors.

Baker and Johnson argued that obtaining commercial imagery data is only the first step in translating informational awareness into military or terrorist advantages. The assumption that access to imagery (revealing the disposition and operations of military units) translates into detrimental actions against such units should be based on concrete knowledge that adversaries have the technology and talent to interpret acquired imagery (or, can at least contract those tasks out) and then use such interpretation to launch an attack. Imagery interpretation (once called photo interpretation, now often called imagery analysis) is a difficult task, and even the best interpreters/analysts can make mistakes concerning geospatial objects and signatures. As remote sensing experts Florini and Dehqanzada note, "Satellite imagery is hard to interpret. Junior analysts are wrong far more often than they are right."[40] Moreover, as Baker and Johnson see it, "Today, few foreign militaries possess anything like the capabilities, expertise, and experience necessary to translate satellite imagery data into information that directly contributes to a significant military advantage on the battlefield…"[41] In a separate article, Baker revealed a major knowledge gap associated with imagery interpretation between what he calls imagery activists (and other user groups) and trained remote sensing professionals:

> They [i.e., novice imagery users] generally lack training, experience, and resources required to make consistently accurate interpretations of overhead images, particularly when compared with more-experienced imagery analysts found at government agencies, commercial remote sensing firms, and some university departments. This situation creates *an imagery credibility paradox* because, even though new users possess relatively limited experience and resources for developing their imagery expertise, their imagery work is likely to attract high public visibility."[42]

The substantial problem of misinterpretation of remote sensing imagery (a form of knowledge gaps or competency voids) was also emphasized by David Sandalow, Assistant Secretary of State for the Bureau of Oceans, Environment and Science, at a June 2000 symposium on the role of earth observation in international affairs:

> Satellite images have the potential, if interpreted incorrectly, to increase tensions among nations and create confusion during periods of crisis, rather than to promote stability. For example, widespread, incorrect interpretations could confound efforts of U.S. national security agencies to mediate or diffuse tensions along the India/Pakistan, Syria/Israel borders or along the Korean peninsula. This is not just a theoretical problem: in one incident, an image that a magazine claimed was the site of India's 1998 nuclear test turned out to be a livestock pen.[43]

Further, a 2002 CSIS report pointed out that mere acquisition of high-resolution commercial imagery by potential adversaries does not translate into military advantages threatening a state's national security. In one example of knowledge or competency gaps associated with processed imagery data, CSIS reported a newspaper account of military activity near Kabul, Afghanistan (supported by commercial imagery) and that the newspaper "managed to print images upside down."[44] Even then U.S. Air Force Lt. Colonel Larry Grundhauser expressed a keen awareness of the problems with imagery interpretation by non-experts. He argues that, "…there is no reason to assume that mere access to satellite imagery automatically confers to the enemy an ability to use that imagery in a manner that substantially alters the balance of power of the endgame."[45] Nonetheless, his perspective does not seem to resonate with many lawmakers, decisionmakers, or government regulators in the CRS policy arena, since few of them are likely skilled or experienced imagery interpreters or analysts or keenly understand the implications of good vs. bad imagery analyses for national security concerns. It is not so much that non-experts might assume that the technology is autonomous (e.g., computer-enabled automatic feature extraction programs) and thus needs no human skills or inputs, but that non-experts are often unfamiliar with how difficult it is for novice imagery analysts to correctly interpret satellite imagery.

Government officials and bureaucrats are not the only ones who occasionally suffer from the knowledge void syndrome when it comes to policymaking for CRS. Strident advocates of openness policies for earth observation technology also make colossal mistakes in attempting to interpret imagery of political hot spots around the globe. For example, Taylor Dinerman cautions about the misinterpretation and mislabeling of imagery, citing an example portrayed in a GlobalSecurity.org report. According to GlobalSecurity.org, several national news networks, such as BBC, NBC, MSNBC, and CBS, erroneously labeled a satellite photo as an explosion in Iraq, when in fact it was a photo of a well-reported train explosion that occurred in North Korea.[46] Citing another article in *Earth Observation Monthly*, Dinerman quotes Mark Brender, then Vice President for Corporate Communications of Space Imaging, as claiming that "senior media executives don't understand or know about commercial remote sensing."[47] Of course, advocates on the national security side of CRS policy debates could claim that such imagery interpretation mistakes potentially create national security, or at least foreign policy, problems for the U.S., should imagery misinterpretation be the source of such media errors and knowledge deficiencies.

In addition to potential imagery misinterpretations by the media, other knowledge gaps concern the actors involved in remote sensing technology and its history. One example was detected in a September 2001 article in a monthly journal of the American Institute of Aeronautics and Astronautics (AIAA). According to Frank Sietzen, Jr., author and long-time space journalist, "In 1988, France and the U.K. launched a Spot satellite capable of 10-m resolution."[48] Although the spatial resolution was correct, the first SPOT satellite was actually launched by France (Belgium and Sweden were partners, but not the British) on February 22, 1986, and the second SPOT satellite was launched by France (again only with Belgium and Swedish partners) in 1990.[49] The problem with such knowledge voids is that they make it difficult to accurately identify which nations or players are involved in CRS activities and might compete with the U.S. CRS industry and to assess the economic and national security implications of foreign CRS operators.[50]

In addition to technical issues, CRS knowledge gaps can also extend to policy issues. One of the most informative and contentious debates on U.S. CRS technology and its national security implications was between Brian Daily (former White House policy coordinator) and Edward McGaffigan (physicist and senior policy analyst for Senator Bingaman) in the mid-1990s. A strong proponent of minimizing constraints on the U.S. CRS industry, Dailey argued that debates leading up to the Land Remote Sensing Policy Act and PDD-23 were thorough and informed and that the House Committee on Science "vetted the national security issues very carefully."[51] In order to fill a knowledge gap about the potentialities of CRS, Dailey provided the policy background (i.e., eight to ten years of previous debates and discussions on how to commercialize U.S. remote sensing satellites) leading up to the Policy Act and PDD-23. Regarding national security concerns and reflecting an openness perspective, Dailey argued that "proliferation of high-resolution data will probably result in more – not less – regional stability" and that its availability "will result in greater transparence and will promote better decision-making, thereby attenuating possible hostilities that might arise out of ignorance."[52]

Challenging Dailey's perspective, McGaffigan's comments about national security concerns exemplify the difficulty of predicting future forms of U.S. CRS policy. First, he predicted that the CRS policy would not survive "case-by-case" challenges and would therefore be unstable.[53] Nearly a decade later, however, the policy is still in place and has gravitated toward even more accommodation and favorability for the CRS industry. For example, in April 2003, the George W. Bush administration issued a new National Security Presidential Directive (NSPD) on U.S. CRS, which reportedly was crafted and implemented with the help of the Aerospace Corporation, a Federally Funded Research and Development Center (FFRDC) in El Segundo, California.[54] Echoing Dailey's earlier assertion, a major theme of the Directive was that a strong CRS industry would be beneficial for U.S. national security.[55]

Secondly, McGaffigan recounted a conversation with an unnamed individual about the 2002 Policy Act and that the individual called the bill "just the 'LANDSAT' bill" and that the proposed act was supposed to be about how to more effectively manage the LANDSAT program.[56] The recounted statement is another example of partial knowledge voids or incomplete knowledge; although some sections of the bill dealt with Landsat program, other parts covered licensing procedures for CRS satellites and weather satellites. As astutely observed by Gabrynowicz (then professor of Space Studies at the University of North Dakota), people in government often mistakenly called the "Policy Act" the "Landsat Act."[57] While this particular knowledge gap manifestation does not significantly affect the security debate between McGaffigan and Dailey, it does point out problems with officials being unfamiliar with all of the provisions of the 1992 Act and their narrow focus on Landsat vs. future CRS satellites, the latter of which would raise larger security concerns than would the Landsat system. Furthermore, a knowledge gap that muddied this debate was McGaffigan's assertion that, " None of the Armed Services Committees' staff or members realized that the bill [Policy Act] was making fundamental changes in the way we license high-resolution imaging satellites."[58] The problem with this assertion is that it is factually incorrect; the 1992 bill did not make any fundamental changes to the existing CRS licensing regime since it was already in place in the 1984 Commercialization Act. For the most part, the 1992 Act simply replaced the language of the earlier Act. Thus, if any law was to be criticized as being security non-friendly, it should have been the 1984 Act not just the 1992 Act and knowledge defects in this area make one's arguments specious and unfounded.

Finally, McGaffigan's assertion that "only a very limited number of potential suppliers of high-resolution imagery will be around for some time to come"[59] was not quite correct (depending on the definition of "some time to come"). In addition to his 1996 prediction that, following France, Israel, and Russia, only Japan and India would get into the CRS game,[60] three other nations had or were about to launch high-resolution imaging satellites. As of 2006 (ten years from McGaffigan's prediction), the following additional countries had orbited or planned to orbit satellites with resolutions of 2 meters or less: Germany (TerraSAR-X radar imaging satellite, 2006), Korea (KOMPSAT/Arirang-2; 2006), and Taiwan (FormoSat/RocSat-2 ; 2004), etc.[61]

Even as far back as 1997, Washington Times columnist Bill Gertz reported U.S. sources as estimating that by the year 2000 there would be several new entrants to the high-resolution satellite imagery club, with member states consisting of Pakistan, China, Brazil, Italy, Spain, Germany, Ukraine, South Korea, and the United Arab Emirates (UAE).[62] Of course, it is important to point out that, depending on Gertz's definition of high-resolution imagery, Pakistan, China, Brazil, Spain, Ukraine, and the UAE were still not on the horizon as of 2007, if GSD imaging capabilities is considered to be 2 meters or better. The point here is that policy officials taking the line that the U.S. had nothing to fear from international competitors in the high-resolution earth observation business in the mid-term is like kicking the policy can down the road. It also manifests a lack of knowledge about foreign CRS programs (current and planned) and thus hampers well-informed debates on CRS policy issues.

CRS industry official often seem to have more insights into what constitutes good CRS policies and regulations. A key player in the CRS arena and industry advocate for fewer governmental restrictions on commercial space-based imaging is Mark Brender of Space Imaging. When I spoke to Mr. Brender in 2004, he conveyed to me the importance of CRS and the milestones achieved by Space Imaging in space-based earth observation activities. Back in July 1996 (approximately two years after the Clinton Administration's PDD-23), Mr. Brender, a strident advocate of the openness/transparency side of policy debates on remote sensing, served as the Chairman of the Radio-Television News Directors Association's (RTNDA) Remote Sensing Task Force before the Subcommittee on Space and Aeronautics of the House Committee on Science. During his testimony to the Subcommittee debating the proposed Space Commercialization Promotion Act (SCPA) of 1996, Brender commented on RTNDA's efforts to encourage the USG to promote the CRS industry. According to Brender, "RTNDA seeks greater availability of high resolution earth images for use by the news media to inform the American public, free from unwarranted government interference."[63] At the hearing, Brender voiced RTNDA's intention to seek modification of existing U.S. laws and policies governing CRS on the basis of First Amendment free speech and free press principles and claimed that the Clinton policy in PDD-23 and the proposed legislation of the SCPA are [were] "unconstitutional."[64] Of high concern were the provisions for shutter control (particularly when imaging the State of Israel), which is discussed in detail in the next section.

Although much of the literature on CRS emphasizes the advantages of commercial observation imagery for creating transparency conditions leading to reduction of conflicts (as particularly highlighted in several contributions to the book entitled *Commercial Observation Satellites*),[65] there have been some experts in remote sensing technology and its implications for public policy and international relations who have different viewpoints. For example, Vipin Gupta, a senior member of the technical staff at Lawrence Livermore National Laboratory, argued that high-resolution CRS imagery distributed on a global scale could negatively impact balances of power or provide advantages to nations possessing asymmetric military capabilities.[66] According to Gupta, richer and more power nations could purchase imagery through exclusive agreements with CRS operators or vendors, thus denying targeted or competing states the ability to acquire such imagery.[67] Gupta's perspective reflects both sides of the political/technological coin. CRS can add to transparency and hopefully ameliorate tensions and uncertainties about a nation's intensions, but it can also contribute to conflicts and tensions by providing states (that purchase imagery data) with military, political, and economic advantages to the detriment of opposing states and concomitantly create "a new class of states that feel blind and exposed,"[68] in Gupta's terms.

Although not mentioned by Gupta, such limited purchasing agreements might be called into question, legally, since U.N. principles mandate that all sensed/imaged states be allowed to acquire imagery taken of their territory at reasonable costs. The United Nation's *Principles Relating to the Remote Sensing of the Earth from Space* (1986) states (in Principle XII) that "As soon as the primary data and the processed data concerning the territory under its jurisdiction are produced, the sensed State shall have access to them on a non-discriminatory basis and on reasonable cost terms."[69] Limited purchasing agreements could potentially come into conflict with this U.N. principle. Should the principle be evoked or implemented in any particular case, limited or preferential sales of CRS data would be problematic and highly contentious. For example, the USG executed an exclusive purchasing agreement in 2001 with Space Imaging for CRS imagery of Afghanistan.[70] Since, at the time, the Taliban was the Afghan "State," it could have requested the same imagery under the U.N. principles, but probably didn't have the financial means or strategic plans to do so, or might not even know what to do with the imagery had it been able to purchase it (perhaps with help its few allies or supporters in the region). Nonetheless, other more plausible cases could arise in the future that could complicate the economically driven practice of limiting CRS imagery to players other than sensed states. This points out the contrast between the egalitarian principles of the U.N. resolution and global economic and geopolitical factors of CRS imagery sales in the post-Cold War era.

Not only would CRS imagery create tensions between opposing states, Gupta argued in 1995 that it could even produce tensions or conflicts between friendly, allied states. One scenario painted by Gupta would be a situation where one nation sells imagery to a favorite client state to the possible detriment of other allied states among a larger alliance of states in which the selling state belongs.[71] In the complicated arena of international politics, a myriad of asymmetrical advantages and disadvantages could be created by the distribution of CRS data as instruments of political power in the international market. In 2001, with more experience in research in this esoteric field of remote sensing politics, Gupta teamed up with Adam Bernstein (a physicist at the Livermore Branch of Sandia National Laboratory and an expert on the technological approach to threat verification and monitoring),[72] to study the political implications of CRS in the South China Sea. Their research focused on the interstate conflicts over physical occupation and claimed ownership of the Spratly Islands by China, Vietnam, Taiwan, Brunei, Malaysia, and the Philippines. Gupta and Bernstein concluded that remote sensing imagery (both space-based and aerial) could potentially defuse military clashes by making them internationally unpalatable or embarrassing or potentially "dispel false accusations of physical occupation"[73] by competing states. Yet, what they failed to acknowledge is that increased informational awareness provided by remote sensing satellites (or aircraft, for that matter) concerning increased military or civilian incursions or buildups among the islands could actually bolster national calls for political, economic, or military action against other states involved in disputes over the Spratleys. Notwithstanding, this example reemphasizes the dual-use nature of CRS, which has sparked intense controversy and policy debates over national security vs. transparency issues.

Resolution and Shutter Control Policies

Spatial Resolution Policy Issues

Commercial imaging satellites that give rise to national security concerns are those that are characterized as having high spatial and spectral resolutions. Spatial resolution capabilities are associated with the ability to distinguish separate objects on the earth and spectral resolution capabilities are associated with ability to distinguish reflectance characteristics of earth objects within a pixel of a given number of meters. Spatial resolution technically means the number of pixels in an image that allows one to distinguish adjacent objects of a certain size. A spatial resolution or pixel count that allows one to distinguish a 1-square meter object from its surrounding background would be a 1-meter ground sample distance (GSD) resolution. High-resolution imaging capabilities in the electro-optical (EO) spectrum range are generally considered to be in the 2-meters or less range. Medium- and especially low-resolution imagery data of the earth (e.g., Landsat images in the 15- and 30-meter ranges) are not as useful for military purposes as they are for scientific and other commercial uses, and thus are not much of a national security concern. As of late 2005, Space Imaging, DigitalGlobe and Orbimage had orbited and operated land remote sensing satellites with 1-meter or better resolution and those systems have given rise to concerns over the security and foreign policy implications of such imagery.

When crafting CRS policies and regulations, political and bureaucratic actors consider resolution capabilities of imaging satellites when deciding whether to grant CRS companies licenses to operate CRS systems. This is particularly true of DOD and DOS in their roles of providing consultation and advice to DOC and NOAA for licensing decisions. High-resolution imagery can provide potential adversaries with military advantages that officials within the U.S. national security establishment might not desire to have available on the international market.

Yet some military officials have discounted the paranoia associated with the national security implications of high-resolution imagery. For example, in 1998, although not writing as an official spokesman of DOD, Grundhauser published a study in a USAF journal at the U.S. Air War College that addressed the implications of high-resolution CRS imagery for U.S. national security. In the well-documented study, Grundhauser questioned the debates and rationale for concern over spatial resolution capabilities of commercial satellites. According to Grundhauser, "It is vitally important to move beyond the simplistic notion that spatial resolution is the deciding factor as to where a particular system may pose a threat to national security. In fact, moderate resolution spectral data from multiple sensors may actually present a greater threat than does high-resolution panchromatic imagery alone."[74] Of course, to comprehend these technological aspects of resolution issues, one needs to have a significant grounding in remote sensing technology and its capabilities – something that few political actors (legislators and administration decisionmakers) would normally possess. Essentially, this condition likely constitutes a knowledge void detrimental to effective CRS policymaking and regulation.

In the early 1990s, a common perception among many analysts and officials on remote sensing issues was that policy changes were drastically needed to address the spatial resolution issue, largely due to the French SPOT system that provided 10-meter GSD imagery. For example, while participating in debates on this topic, General Thomas S. Moorman, Jr., noted, "The issue of government policy concerning remote sensing was one of the hottest issues of the early 1990s."[75] Moorman categorized two distinct policy groups during the early 1990s debate period as consisting of industry, scientists, and environmentalist in the camp of relaxing resolution constraints, and the military and intelligence community in the other camp that advocated placing restrictions on resolution capabilities and remote sensing data distributions. Those policy debates ultimately led to the passage of the Land Remote Sensing Policy Act of 1992.

Another military officer commenting on spatial resolution issues that potentially affect U.S. national security was J. Todd Black (cited earlier in the chapter). According to Black, "Discussions of resolution can quickly become highly complex;"[76] That assertion was absolutely correct and demonstrates a keen awareness of the technological aspects of CRS policy issues. However, possibly due to incorrect knowledge, Black wrote that PDD-23 stated, "Dissemination of imagery with resolution of one meter or less might be harmful to U.S. national security."[77] As previously mentioned in this chapter, the only publicly available document (which was also acknowledged by Black) on the 1994 policy document is a 3-page White House fact sheet on PDD-23. Nowhere in that document is there any mention of "imagery resolution of one meter or less" or that such high-resolution imagery "might be harmful to U.S. national security." In fact, as pointed out by others and elsewhere in this dissertation, the PDD-23 fact sheet does not mention imagery resolution restrictions at all. It simply states that imaging operations can be temporarily restricted when national security, international obligations, or foreign policy interests might be compromised, as determined by the Secretaries of State and Defense. Since the incorrect information did not come from the PDD-23 fact sheet itself, this misconception could have stemmed from another source in the reference note (No. 8) to the article: Bill Sweetman's 1997 article in AIAA's journal *Aerospace America*. Sweetman discussed PDD-23 but did not state national security-dictated resolution parameters were included in its wording. The only thing close to this in his discussion of PDD-23 was his observation that:

> The US Administration's response is Presidential Decision Directive 23 (PDD-23) issued in 1994. This allows US companies to develop meter-resolution satellites for commercial use, to do so in conjunction with non-US government and industrial partners and to offer their imagery on the commercial market – provided that the US government can block out coverage at any time or place when dissemination of imagery would harm US national security.[78]

It is highly possible that the complexity of policy and legal regimes for CRS caused this knowledge gap manifestation. For example, Black's article also cited Ann Florini, who's 1988 analysis predated PDD-23 by at least five years. Florini did mention another much earlier Presidential Directive from the Carter administration, as follows: "President Carter's Presidential Directive 37, issued in June 1977, reportedly limits the resolution of U.S. civilian remote-sensing satellites to no better than ten meters.[79] Perhaps Black confused the contents of this earlier directive. Other than Carter's Directive, research did not identify another PD or PDD (at least from fact sheets (which are usually the only open-source, publicly available documents summarizing the policies contained therein) that specifically mentions a particular GSD resolution evoking national security concerns.

To demonstrate how such knowledge gaps or inaccuracies are propagated, one only needs to do an Internet search on the quoted phrase above to come up with either Black's article, or more tellingly, a reference to it in another article written by David Willson using a U.S. Army perspective on CRS.[80] This so-called "[U.S.] Army view" was written for a USAF legal journal.[81] Willson's otherwise well researched law article incorrectly uses Black's quote about PDD-23, stating that dissemination of 1-meter imagery could be a threat to national security.[82] Even though, at the time of PDD-23 (1994), 1-meter resolution probably was considered to be threatening to national security and might even be so today (under certain circumstances), the repetition of the erroneous quote simply demonstrates propagation of inaccurate information spawned by knowledge gaps. Fortunately, accurate portrayals of the fact sheet are available. For example, after describing the intent of the policy (i.e., PDD-23) Lawrence Fritz, past president of the International Society of Photogrammetry and Remote Sensing (ISPRS) succinctly stated that, "The policy does not set a limit on spatial resolution."[83] To compare verbiage cited above with that of the 1994 document, the fact sheet to PDD-23 is included as Appendix C.

Assertions based on knowledge gaps can lead to replication of unintended misinformation. Whether or not this has consequences for CRS policymaking is hard to say. One or two research errors might not be overly problematic, but an amalgamation of distorted facts and misinformation can not help but influence the thinking of those in charge of legislating and regulating the CRS industry. In an apparent attempt to fill these knowledge gaps with accurate information, Dequanzada and Florini pointedly noted that, "Although there is a widespread myth that Presidential Decision Directive [PDD]-23 limits the resolution of American satellites to no better than 1 meter, in fact there is no constraint on resolution."[84]

Shutter Control Policy Perspectives

Shutter control remains a most controversial element of the U.S. regulatory controls over the commercial remote sensing industry.

– Kevin O'Connell and Gregory Hilgenberg (2001)[85]

… the licensing regulation and implementation of shutter control is ambiguous, lacks explicit criteria, and is not defined narrowly enough.

– Space Enterprise Council (2005)[86]

According to John Baker, a leading expert on CRS policy at the RAND Corporation, differing perspectives and debates on shutter controls emerged even before the first high-resolution CRS satellite (Ikonos-2) was successfully placed into orbit in 1999 by Space Imaging.[87] In 2003, Baker wrote that the two key groups contending over shutter control policies and regulations were, of course, the USG and the CRS firms. As Baker noted, "Top managers at the U.S. commercial satellite firms charge that uncertainty over the U.S. government imposing shutter control drives away potential investors and foreign customers."[88] Since then, other groups such as media representatives and imagery activists have entered the fray.

Shutter control restrictions were first mentioned in PDD-23; the Clinton administration's policy limited imaging when national security, foreign policy, or international obligations were at risk. CRS industry leaders have voiced concerns about the specificity of the "shutter control" policy reflected in PDD-23. In fact, shutter control became a very contentious issue in 1999 when it was spelled out in greater detail (than in PDD-23) in NOAA's proposed regulations. According to Ben Iannotta, the 14-page draft regulation generated heated reactions from the CRS industry and news media officials alike.[89] Reportedly, NOAA backed down in the face of such protests to significantly revise the regulations. Future versions of NOAA's regulations were to be vetted in the public domain or at least after considering public comments along with inputs from other government departments and agencies.

Commenting on "shutter control" policies, a euphemism for licensing restriction imposed by NOAA on CRS satellite operators, Florini and Dehqanzada note that the policy raises several problematic issues.[90] First, restricting U.S. CRS satellite imaging during unspecified periods of crises or when such operations could compromise U.S. national security or international obligation defeats the goal of the USG in promoting a robust and competitive CRS industry.[91] Secondly, as Florini and Dehqanzada and others have recognized, imposition of shutter control restraints on CRS operations could run into First Amendment constitutional challenges.[92] Finally, since many other foreign CRS operators might not be subjected to the same constraining regulations, limiting operations of US commercial imaging satellites would just mean that potential purchases of CRS data could always go to foreign sources for such information, particularly lately, when many foreign systems are very competitive with US CRS systems. Addressing this possibility, Florini and Dehqanzada note:

> It is not clear that shutter control will do much to protect U.S. interests even if it survives such a challenge [i.e., court challenge]. Although the U.S. satellites will be more advanced than any of the systems currently in orbit [i.e., as of July 1999], they hardly have the field to themselves. Given the large number of alternative sources of imagery, certainly shutter control by itself is not going to protect U.S. interests in the long run."[93]

One wonders if the crafters of the shutter control policy realized this potentiality and perhaps the futility and ineffectiveness of such a policy in the long run. Could this also be indicative of a knowledge gap in formulating effective CRS policy? Or was it a typical way for the USG to remain purposefully vague in its policy language by not specifying conditions under which shutter control would or could be imposed? In 2001, RAND summed it up nicely:

> Even if U.S. officials could specify the contingencies in advance, they are unlikely to give up their policymaking leeway for deciding under which conditions to impose shutter control. Thus, a natural tension exists between the desire of U.S. commercial firms to reduce the uncertainties that could affect their business operations and the overriding interest of the U.S. government to preserve its policymaking flexibility for employing shutter controls in largely unforeseeable circumstances."[94]

Of course, it needs to be pointed out that shutter control mechanisms have not been used to date by the USG. Instead, other pseudo-shutter control methods, termed "persuasion to buyouts" by Theresa Hitchens, Vice President of the Center for Defense Information, have been employed, with "mixed" results.[95] An example of imagery buyouts occurred during post-9/11 U.S. military operations in Afghanistan, when (as mentioned earlier) the then NIMA purchased all of Space Imaging's satellite images of Afghanistan to keep data on U.S. military operations there from falling into the wrong hands.[96]

In October 2001, GlobalSecurity.org commented about shutter control and the fact that it had not been imposed since the regulation's inception. Perhaps reflective of a knowledge gap, GlobalSecurity's *Defense Information and Electronics Report* misleadingly stated, "In the seven years [that] the authority has existed, shutter control has not once been imposed, according to the Commerce Department."[97] Actually, the authority to restrict CRS space imaging could not have been imposed until the first operational CRS satellite was successfully placed into earth orbit, and that did not occur until Orbital Sciences Corporation successfully orbited its Orbview-2 (SeaStar) imaging satellite in August 1997. The Orbview-2 satellite was really a hybrid civil/commercial satellite, which carried a 1-km resolution multispectral sensor for NASA, but provided low-resolution imagery to the commercial fishing industry.[98] Because of its low resolution, it is highly doubtful that shutter controls would have been imposed on that system by the USG for any reason. Most likely, shutter controls would only have been imposed upon the operations of Space Imaging's Ikonos-2 satellite (capable of 1-meter panchromatic and 4-meter multispectral imagery) launched in 1999. Thus, the "seven years" was not an adequate or valid measure. It should have been characterized as about two years or about four years at the most (in either case, a much shorter timespan). Here the knowledge void indicator was either not knowing or not considering the fact that the only satellite that would have realistically been targeted for potential shutter control restrictions was Ikonos-2 (launched 1999, 5 years after PDD-23) and assuming that the U.S. was sparing in the use of its shutter control authority.

Glaring knowledge voids are also often manifested in media/think tank reports on shutter control issues. In the same GlobalSecurity.org report, the question was asked: "So why has shutter control never been imposed?"[99] In the answer to that question, it was claimed that CRS companies can be prohibited from selling imagery to agents of foreign nations or to terrorists by the constraints DOS's U.S. Munitions List [USML]: "Such imagery sales are already prohibited by the same State Department export controls that govern the sale of conventional military equipment abroad."[100] Although that statement might be true for enemy states or terrorist groups, it is not a blanket restriction of imagery distribution to agents of a foreign nation. DOS-administered USML provisions cover (among other things) exports of remote sensing systems (hardware) and technology (know-how), but not imagery data. They clearly define sensitive technology as consisting of items on the USML that are "necessary to develop or to support advanced remote sensing space capabilities and which are uniquely available in the United States."[101] To reiterate, PDD-23, which was still in effect at the time of the GlobalSecurity.org report (but later replaced by George W. Bush's 2003 policy on CRS), covers transfer of advance remote sensing capabilities and systems, not the imagery data.[102]

Such knowledge gaps even extended to the apparent unfamiliarity with the previously mentioned 1986 U.N. Principles, which proclaims in Principle XII that a sensed state can have access to satellite imagery of its territory as soon as such data is produced by a space imaging system.[103] Moreover, had due-diligence research been conducted on this issue, one would have come across the February 9, 1994 Congressional hearing on commercial remote sensing, which would have clarified this common misconception. In the hearing report section entitled "Exporting Hardware vs. Imagery Distribution," Congressman Dan Glickman, Chairman of the Senate's Permanent Select Committee on Intelligence, referred to the lack of public knowledge on CRS technology and policy by stating, " I mean we're talking about remote sensing and all these kinds of *obscure* subjects [italics mine]."[104] Later in the Hearing, Scott Pace of RAND clarified this confusion about technology/systems transfer vs. imagery data restrictions:

> The United States categorizes remote sensing systems as 'munitions' and thus part of the U.S. Munitions List (USML) managed by the Department of State. … It should be noted that technology and hardware are subject to U.S. export controls, not the remote sensing data products produced by civilian systems. Thus, the export of a ground station or satellite may require a government [export] license, but not the reception of unencrypted data from space.[105]

Another form of shutter control is embodied in the Kyl-Bingaman Amendment (Amendment No. 4321) to the National Defense Authorization Act for FY 1997, concerning the prohibition of acquisition and distribution of satellite imagery of Israel or other countries designated by the President. The Amendment specified that U.S. CRS firms could not image or disseminate satellite-sensed data on Israel if the GSD resolution of such exceeded was better than that which could be obtained from other commercial satellite imagery sources.[106]

Predictably, industry perspectives on government policies and regulations governing CRS operations lean towards more flexible and less constraining controls. During the Spring 2003 ICAF Seminar on space industry issues, Matthew Mayer of the Boeing Company (a firm that builds satellites and launch systems) provided an outlook typical of the CRS industry on the oft-characterized incoherence of government policy and regulations on CRS and the reluctance of the USG (particularly, DOD) to partner with CRS firms.[107] This proclivity began to change with the George W. Bush administration's 2003 policy on remote sensing and the ClearView and NextView contracts with NIMA (now NGA). Despite these commercial gains by the CRS industry, however, shutter control was still contained in the George W. Bush administration's policy, the 2000 interagency memorandum of understanding (MOU) on licensing of private remote sensing satellites, and NOAA's regulations, and it continued to be a nagging issue because of its open-ended provisions and potential to diminish industry profits and damage credibility with creditors and domestic and international customers.

Although shutter control enforcement actions have yet to be taken by the USG to prevent U.S. satellite operators from imaging sensitive geographical regions where the U.S. military conducts its operations, DOD has invented clever mechanisms to accomplish shutter control without actually invoking formal enforcement actions. Such mechanisms involve agreements with U.S. CRS firms to distribute its imagery of sensitive areas to USG entities. Since the Government is a key patron and financial backer of U.S. CRS (NGA is the industry's biggest customer), it is probably difficult not to enter such "back-door" shutter control agreements. As mentioned earlier, shutter control orders were not issued during post-9/11 operations in Afghanistan.[108] Mayer commented during the ICAF seminar that instead of the USG exercising its shutter control options, "it chose the more politically palatable option of buying all the precise images of Afghanistan available during the conflict."[109] This form of de facto shutter control most likely came from the January 4, 2000 MOU. The methodology for implementing shutter control was spelled out in the MOU, but, interestingly, the final clause in paragraph B(2) states that alternatives to physical shutter control, such as "delaying the transmission or distribution of data, restricting the field of view of the system, or encryption of the data if available,"[110] could be "other means to control the use of the data."[111] Perhaps it is a coincidence, but "other means to control the use of the data" could arguably be political/economic restrictions through exclusive buyout contracts between the USG and CRS operating firms, as in the case of the Ikonos imagery purchase from Space Imaging by the then NIMA.

Perhaps this pseudo-legal/regulatory method of controlling dissemination of imagery deemed to be of national-security interest might be more politically palatable. Yet, it doesn't seem to solve the inherent problem of distrust (by international purchasers of U.S. imagery data) of the U.S. CRS industry's capability to reliably provide high-resolution imagery on the world market. Essentially, imagery buyouts are only a temporary fix to the perceived problems with USG policies and regulations on satellite shutter controls. Such provisions can also alienate non-government users of CRS data, such as NGOs and humanitarian groups. According to David Corn, Washington Editor of *The Nation*, high-resolution imagery of Afghanistan could have assisted refugees and displaced non-combatants in that conflict to enable humanitarian aid to reach needy recipients.[112] While shutter control has not been imposed since its inception, it continued to be a psychological problems for the U.S. CRS industry in competing with foreign CRS systems, the subject of the next section.

Foreign Competition Issues

The U.S. is attempting to cover the external world with a techno-impervious blanket; however, instead of keeping the world at bay, it's freezing out U.S. industry.

– Space Industry Seminar (Spring 2003)[113]

Current regulatory conditions are hampering the ability of American companies to compete with foreign competition on a level playing field.

– Aerospace Industries Association (2004)[114]

The issue of foreign competition in remote sensing and the challenges it poses for the viability and growth of the U.S. CRS industry is closely related to the aforementioned topics of national security, information transparency, and shutter control policies and regulations. It is also one of the most esoteric and complex of the CRS policy issues because of the multitude of nations now designing and operating non-military remote sensing satellites. In order to comprehend the impact of foreign competition in this high-technology arena of earth observation satellites, it is incumbent upon current and future USG policymakers and regulators to keep abreast of the rapid advances made in this technological field by several nations around the globe. Unfamiliarity with this aspect of remote sensing policy (i.e., potential knowledge gaps) makes it difficult to craft and implement effective and practical policies and regulations governing the U.S. CRS industry.

In 1994, OTA conducted a study of earth observation systems and applications for potential development of a strategic plan to harness the capabilities and powers of earth observation satellite technology to provide valuable data about the earth. Part of that study dealt with foreign competition issues for U.S. civil and commercial remote sensing policymakers. Concerning the implications of giving more weight to national security over that of commercial competitiveness, OTA concluded that, "The changing international scene also poses new challenges to U.S. competitiveness in commercial remote sensing and forces a reconsideration of national security interests in remote sensing technologies."[115] Moreover, in 2003, John Baker noted that the once dominant position of the U.S. in civil and CRS activities was rapidly shrinking.[116] His observation was that a knowledge gap existed in grasping the nature and extent of foreign competition facing the U.S. in CRS activities and capabilities. According to Baker, "It's largely overlooked that foreign governments and a few foreign firms are expected to account for the lion's share of expected growth in civilian and commercial observations satellites."[117]

The CRS competition landscape was not visible until France launched its first remote sensing satellite, called Satellite Pour l'Observation de la Terra (SPOT-1), in 1986 and quickly overtook the Landsat Program in sales of satellite imagery. India quickly followed suit by launching its IRS-1A earth observation satellite in 1988. These events placed pressure on the U.S. to figure out how to promote its own CRS industry and eventually prompted the U.S. Congress to pass the Policy Act of 1992, which reauthorized the licensing of U.S. CRS firms. To implement that legislation, the Clinton Administration issued PDD-23 less than two years later on March 9, 1994, which dealt, in part, with foreign sales of U.S. CRS imagery and foreign access to U.S. CRS systems and technology.[118] The Directive attempted to balance U.S. national security concerns with the goal of promoting the U.S. CRS industry and its competitiveness in the global market for CRS systems and data.

A guiding principle of PDD-23 was that of comparable capabilities, a condition that had to exist to allow U.S. CRS firms to obtain licenses for CRS systems and to market commercial imagery and CRS satellite technology to foreign customers. Yet, the CRS industry and advocates for that sector noted the vagueness of the Directive on this issue. To rectify the weak policy for U.S. CRS, the U.S. Aerospace Industries Association (AIA) proposed to the George W. Bush administration that PDD-23 be revised.[119] While noting the deficiencies of PDD-23, AIA reported that they were instrumental in crafting the new 2003 policy on CRS for Bush administration.[120] Of note, the Aerospace Corporation and the U.S. Chamber of Commerce's Space Enterprise Council (an advocacy group for the commercial space industry) also played a significant role in helping shape the new policy for CRS.

Others actors in the aerospace industry had similar concerns about policy constraints on the U.S. CRS industry's ability to favorably compete with foreign states and firms already in or entering the CRS market. Almost four years after the issuance of PDD-23, Congress began considering and debating a bill that later became the Commercial Space Act of 1998. On February 27, 1998, Space Imaging (then Space Imaging L.P.) submitted a letter to Senator Bill Fritz of the Senate Commerce Committee's Subcommittee on Science, Technology, and Space. In that letter, then Space Imaging CEO John R. Copple voiced concerns over the future viability of the U.S. CRS industry and its ability to compete in the global remote sensing market. Copple was also concerned about DOD's and DOS's role in the USG's jurisdiction over CRS operations.[121] The details of the letter reflected interagency conflict over USG roles in regulating the CRS industry and pointed out that virtually open-ended review of licenses applications of the CRS industry by DOD and DOS created untenable uncertainty for business planning.[122] Moreover, Copple noted that foreign competitors in the CRS arena do not face the same degree of regulatory uncertainties.[123]

If Congress (in this case, the Senate) was not aware of this situation (a potential knowledge gap), Copple attempted to clarify it. Predicting the foreign response (particularly foreign investors in U.S. CRS systems) to the condition of regulatory uncertainty, Copple opined, "The market will ask, why do business with a U.S. company when you don't know when or if you will ever have an agreement, when you can do a similar deal with the Israelis, French or Russians and have a deal today?"[124] As if to educate U.S. legislators about foreign competition in the CRS arena, Copple pointed out that France, Russia, and Israel were all working on designing and launching 1-meter resolution remote sensing satellite in the near future.[125] According to the Space Imaging CEO, the U.S. lead in CRS would be seriously eroded if regulatory ambiguity, uncertainty, and opaqueness were not addressed and fixed in the proposed legislation.[126]

When debating and drafting CRS legislation, Congress needs to have accurate information on the issues of foreign competition faced by the U.S. CRS industry. Most importantly, Congress needs to know the technical capabilities of foreign CRS systems to provide favorable laws to preserve U.S. leadership in the global CRS arena. Unfortunately, Congress often relies on information (of varying degrees of accuracy) provided by witnesses at CRS-related

Congressional hearings. One such example involved a witness in the 1997 Congressional hearing on the proposed Commercial Space Act who correctly stated that the U.S. did not possess (as of 1997) anything better than 30-meter resolution (i.e., Landsat-5),[127] whereas another witness incorrectly stated that the best foreign commercial satellite imagery in the world [as of May 1997], was that delivered by the Indian IRS-1C satellite [5.8 -meter pan; launched in Dec 1995].[128] Actually, commercially available 2-meter satellite imagery [albeit, film based] had been available from two Russian firms (Sovinformsputnick and Priroda) since 1992.[129]

Other examples of knowledge voids on resolution capabilities provided by foreign satellite imaging systems (as potential competitors to the U.S. CRS industry) are readily evident in the CRS literature. Like the Congressional witnesses, Deborah Foster, research analyst at Scientific Applications International Corporation (SAIC) specializing in foreign satellite systems research, erroneously stated, "India has capitalized on its remote sensing capabilities since the early 1990s, providing the highest-resolution panchromatic imagery (5.8) regularly available in the commercial market."[130] The operative term might be "regularly," but as previously noted, Russian systems at that time were capable of delivering 2-meter panchromatic imagery in the commercial marketplace

Recognizing such knowledge voids concerning foreign CRS systems, William Stoney, lead engineer at Mitretek, discussed foreign CRS systems at the second meeting of NOAA's Advisory Committee for Commercial Remote Sensing (ACCRES) held on January 14, 2003. According to Stoney, "…nobody is looking at the total picture concerning civil satellites."[131] In addition to concerns over competitiveness of U.S. CRS technology, issues over delays in CRS licensing decisions and regulatory controls over CRS satellite operations are also of concern. Perhaps reflective of either the government's, industry's, or general public's unawareness of, or lack of interest in, CRS issues, particularly involving NOAA's licensing regime, Tim Stryker, former NOAA licensing coordinator, revealed (during the fourth ACCRES meeting on December 11, 2003) that NOAA only received four responses to a request for information (RFI) calling for public comments on CRS regulations and ways to improve NOAA's licensing procedures. Reportedly two of the comments came from ACCRES members themselves and the other two came from the CRS industry.[132] This was a startlingly miniscule response rate and indicative of either poor dissemination of the RFI or apathy (and possibly unfamiliarity with the issues) on the part of the general public or the government itself.

Scientific and Economic/Market Interests: Impact of Foreign Systems and Policies

Scientific Interests and Issues

Much of the general literature on the policy implications of CRS appears to focus on U.S. national security, foreign policies and international obligations, and the health of the U.S. CRS industry (i.e., market interests and issues), instead of the influence of the U.S. scientific community on CRS legal, policy, and regulatory regimes. Often one reads that scientific interests in earth observation data are met by the availability of large-area, medium- to low-resolution U.S. civil satellite imagery, such as that provided by Landsat-5 and -7 and other civil earth observation systems. Yet, the U.S. scientific community is (or should be) interested in

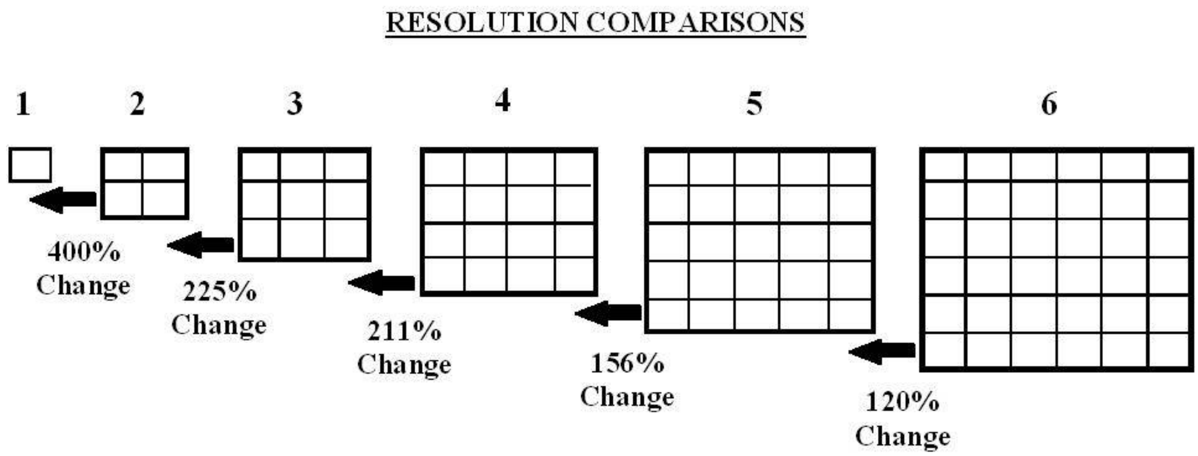
CRS imagery and would rightfully be concerned about policy and regulatory restraints placed on CRS systems capable of providing earth observation imagery.

Capabilities provided by commercial observation satellites that are of interest to scientists run the gamut from agricultural and environmental monitoring to forestry, geology (e.g., mineral, gas, and oil exploration), mapping, and a variety of other applications. Articulating the interest of scientists in future CRS systems, Susan Moran, a physical scientist for the Southwest Watershed Research Center of the U.S. Department of Agriculture, provided testimony on precision crop management at a hearing held by Congress (Committee on Science, Subcommittee on Space and Aeronautics) on May 21, 1997. The Subcommittee was working on a bill for the proposed Commercial Space Act of 1997 (which latter became the Commercial Space Act of 1998 – P.L. 105-303) on October 28, 1998. During her testimony, Moran emphasized the "the value of commercial … remote sensing industry …to the scientific community [particularly for precision crop and soil management]."[133] Many of the scientific applications of CRS are highly esoteric (particularly when they involve multispectral, hyperspectral, or thermal imaging capabilities) to a nonscientific forum such as a Congressional committee/subcommittee, but at least this field (i.e., applying science to agriculture) presented by Moran portrayed the scientific and economic value of CRS.

Also testifying at the May 1997 hearing was Professor John Townshend, Chairman of the Department of Geography at the University of Maryland (College Park), who articulated the benefits of CRS to other areas of interest to scientists, particularly in the new discipline called earth sciences. Most importantly, he attempted to educate the legislators on the value of high-resolution imagery (e.g., 1-meter panchromatic imagery) to the scientific and academic community. Specifically, Townshend noted, "In my judgment, the most important is the very fine detail they [future CRS systems] will be able to detect, as fine as three feet across. In essence, 100 percent improvement on what is currently generally available."[134] In this case, Townshend might have been referring to 2-meter imagery available since 1992 from Russian satellites.[135] Yet, even assuming that the best existing systems at the time provided 2-meter resolution, then a movement from 2 meters to 1-meter capability would actually be a tripling (300-percent) or quadrupling (400-percent) improvement, depending on conceptualization of the percentage of increase. For example, 2-meter GSD resolution is actually 2 x 2 meters or 4 one-square meters which is a factor of 4. Perhaps this slight knowledge gap or slip on the resolution factor was an attempt at simplification to aid comprehension by non-experts in the technical aspects of remote sensing.

To fill a knowledge void on resolution capability/proportionality ratios, one only needs to review studies conducted on this topic by Ann Florini and Yahya Dehqanzada Even back in 1988, Florini noted that, "Perhaps the most misunderstood concept in satellite imagery is that of spatial resolution or ground resolution, referring to the size of the object on the ground that a sensor [actually a human interpreter] can distinguish."[136] Later in 2000, Florini and Dehqanzada descried the proportional differences between spatial resolutions. According to them, "For a satellite with 1-meter resolution, each square in the mosaic corresponds to one square meter of ground area, while 10-meter resolution corresponds to ten square meters on the ground – a difference of a factor of 100 [or one-hundred squares vs. one square]."[137]

To demonstrate that a change from 2-meter resolution to 1-meter resolution capabilities is much greater than just a 100-percent improvement, note the following graphic (Figure 1) depicting percentage step-downs (improvements) in satellite imaging capabilities.



- The number above each pixel box indicates the square-meter area of resolution.
- Movement from a higher to lower number (e.g., 6 meters to 5 meters) increased the resolution capability.
- Although a 2-meter box becoming a 1-meter box might seem like a 100% change, each successive step down does not necessarily mean a 100% change (e.g., 6 meters to 5 meters is a 120% change, whereas 2 meters to 1 meter is a 400% change.
- Movement from 1 meter to .5 meter might seem like a 100% change (doubling in capability), but again, it is a 400% change (or 300% increase), since a squaring function is involved, not just movement from one number to another number.
- One-meter ground sample distance (GSD) resolution means one could distinguish a 1-square meter (approx. 3 square foot) card table from its surrounding background, whereas 2-meter GSD resolution would mean one could only distinguish an object four times the size of the 1-square meter card table from its surrounding background.

Figure 2 – Graphic Representation of the Mathematical Relationships between Successively Smaller Ground Sample Distances (Spatial Resolution Capabilities) Provided by Remote Sensing-derived Imagery Pixels[138]

Returning to the topic of perspectives of the scientific community on CRS, one might question why CRS is needed to support scientific research when the civil Landsat systems are available. The current workhorse for satellite imagery-based scientific data is the government operated Landsat system (Landsat-5 and -7), which is now managed by the U.S. Geological Survey (USGS) of DOI. The more sophisticated platform of the two is Landsat-7, but it currently suffers from a mechanical malfunction of its line-scan corrector, resulting in streaks in imagery scenes downloaded from space. Mechanical or imagery-overlay workarounds have been proposed, while a follow-on Landsat system has yet to materialize.

Even while sensing properly, wide-view imaging systems such as Landsat cannot provide on-demand, point-specific imagery. In contrast, CRS systems designed to cover smaller fields of view than low-resolution systems are able to point their optical sensors off-nadir to target specific areas. The former CEO of Space Imaging EOSAT, Jeff Harris, advised a Congressional committee, on May 21, 1997, concerning such directed observation capabilities, as follows:

> Congressman, one of the important attributes of precision remote sensing is we acquire imagery where we know very accurately where on the Earth we are doing it, so you can take accurate measurements down at the couple meter level. You take that in addition to very similar viewing angles that you can control from a spacecraft, because you are looking from such a distance away the angle variance, as compared to an airplane, is very small.[139]

The first Congressional hearing on the CRS aspect of the proposed Commercial Space Act (H.R. 1702) provided significant insights into the perspectives shared by selected scientists on the value of the technology to scientific research and it obviously generated a lot of excitement among the committee members about the potential of CRS technology. According to Chairman Dana Rohrabacher, "the Subcommittee members who participated in that first hearing seemed unanimous in their excitement about the potential scientific, fiscal, and economic payoff [of CRS systems]."[140] However, such excitement could have been dampened by other views obtained from two key government players in the executive branch, DOS and DOD, during the third hearing on the proposed bill, held on June 4, 1997. Fortunately or unfortunately (depending on one's views), the DOS side did not present its views. Specifically, a representative from DOS did not show up at the hearing, allegedly due to a DOS lawyer having a problem with the CRS aspect of the proposed bill.[141] According to Rohrabacher, "It was a classic Washington bureaucratic maneuver."[142]

Caught in the middle of a policy balancing act, DOC leaned toward supporting the CRS industry (thus also directly supporting the scientific community), whereas DOD obviously was more concerned about the national security implications of commercial satellite imagery. In its stated support of the CRS industry, DOD naturally looks to the military utility of CRS, rather than its scientific utility. In its advisory role in the CRS licensing and operational processes, DOD can recommend to DOC that temporary restrictions be placed on CRS satellite imaging in the form of shutter controls. Yet, shutter control provisions in the CRS regulations have relatively little impact on the work of the scientific community. Conversely, the health and viability of the CRS industry and its ability to provide higher-resolution imagery for particular scientific research requirements was, or still should be, a concern of the U.S. scientific community. Rationally, scientists would also be interested in alternate sources of earth imaging data in the form of CRS imagery, rather than relying on government systems such as Landsat, should the latter not be continued by active government support and funding beyond the life of the existing satellites. In a nutshell, the scientific community seems to be more interested in openness and transparency in earth imaging data (i.e., relatively unfettered information sharing and exchange), whereas the U.S. national security community tends to lean more toward a closed system of protectiveness and information restriction.

That said, the dynamics of conflict and collaboration over CRS data issues are often seen in the relationships between the scientific community and the CRS industry, rather than between scientists and government policymakers and regulators. One of the most contentious issues for the scientific community has to do with intellectual property rights (IPR) over CRS data. The issue concerns industry's claim to IPRs for its CRS imagery data sold through NASA to the scientific community and scientists' needs to widely disseminate such data (and their research findings on it) in scientific journals and publications. The U.S. CRS industry views unrestricted dissemination of its imagery products as eliminating potential new customers for earth observation data. Scott Pace (then a policy analyst at RAND) addressed this issue during an April 29, 1998 seminar at the University of Maryland (College Park). Pace characterized the remote sensing data community as comprising three cultures, the "scientific community, the finance community [probably meaning the CRS industry and its financial backers] and the defense and military community."[143] Later, at a September 28, 1998 Congressional hearing held by the House Subcommittee on Basic Research, Pace commented on the perspectives of scientists and CRS firms concerning CRS data policies. Pace viewed the IPR issue as being a significant barrier to scientists desiring to use CRS imagery data.[144]

One of the most instructive reports on the relationship between government, the CRS industry, and the scientific community stemmed from the March 2001 workshops (entitled "Remote Sensing and Basic Research: The Changing Environment") on public-private partnerships in remote sensing, held by the Space Studies Board of the National Research Council. The stated goal of the workshop was "to summarize the critical issues and perspectives most relevant to understanding the relationships evolving among and between the scientific community and data providers in the public and private sectors in the United States."[145] In summary, the Space Studies Board concluded that, as of 2001, a growing relationship and partnership was emerging at the nexus between the public/government sector (spearheaded, in the case of earth science research, by NASA) and the nascent CRS industry and the scientific community.[146] If borne out, this trend would be indicative of collaboration along the conflict-collaboration continuum.

Reflective of the collaboration end of that continuum, two of the most important initiatives that were warmly embraced by the scientific community for CRS data acquisition and use were the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) program and NASA's program dubbed the Scientific Data Buy (SDB). The SeaWiFS program (involving a partnership between NASA's Earth Science Enterprise Program and CRS satellite operator, Orbimage) is still ongoing. The SeaStar satellite's on-board SeaWiFS sensor system provides ocean remote sensing data to enable earth science research on global ocean properties. Technically the first hybrid civil-commercial remote sensing satellite launched in 1997, SeaStar/Orbview-2 provides 1-km resolution imagery of ocean conditions.[147] Orbimage also recently concluded a contract with NOAA to provide both NOAA and NASA scientists with CRS data for environmental research.[148]

The other collaborative effort (SDB) authorized by the Commercial Space Act of 1998 was the most significant legislative act affecting CRS data issues for the scientific community. The SDB program was an experimental effort to encourage the use of commercial satellite imagery by the earth sciences community and was managed under the Commercial Remote Sensing Program (CRSP) at NASA's Stennis Space Center in Mississippi.[149] The Commercial Space Act provided funds to NASA to act as a broker for commercial imagery dissemination to selected scientists conducting earth sciences research. Unfortunately, the SDB (an experimental program) only lasted a year.[150] Although a success as an experimental program, the SDB was short lived and only aided a small segment of the earth sciences community. In fact, many in the scientific community had insufficient knowledge or awareness of the SDB program.[151]

Furthermore, as the administering agency for the SDB program, NASA has been noted as not being very aggressive in promoting CRS for use by the earth sciences community. For example, RAND reported that NASA's missions and culture seemed at odds with full embrace of the SDB program, and that the CRS industry feared that NASA was not interested in developing CRS systems.[152] In 2000, RAND concluded that perhaps NASA did not view the potential success of the SDB "as critical to meeting its science programs."[153] RAND researchers also stated that "The legislative attempt behind the Science Data Buy seems to be in conflict with NASA's traditional institutional interests."[154] Officials and researchers within NASA responsible for space R&D programs saw Congressional funding of CRS imagery purchases for earth science research as competing with funding sources for NASA's traditional space programs.[155] Perhaps this was a knowledge gap on the part of Congress when it passed the Commercial Space Act, creating an intermediary organization or broker in the remote sensing data request-supply chain. Congress might have assumed that NASA would have been extremely knowledgeable about the continuously changing needs of the earth science community and about the products it channeled from the CRS industry to the scientific community. Again, this could have been a case of less-than informed policymaking (or lawmaking), since, in this situation, we add a new dimension to an already complicated field of CRS policy – that of earth science research. It might even have been more cost effective had NASA been taken out of the loop completely and federal funding provided directly to the scientific community (e.g., thru the National Science Foundation or other channels) to acquire CRS imagery directly from industry. Of course, for cost efficiency, a mechanism for bulk purchasing would have needed to be provided. Vouchers and a clearinghouse was one mechanism proposed by the 2000 RAND study.[156] Most instructive in this case is that we can see how technology-related management decisions complicate the political and economic dimensions of U.S. CRS. Here, the lesson learned is that knowledge voids can often be filled with experience: living through bad policy decisions based on knowledge voids and applying lessons learned from such experiences to eliminate future knowledge gaps in comprehending how best to support the scientific community with CRS imagery data.

Market Interests/Foreign Systems and Programs

Not only is NOAA the agency that regulates U.S. CRS activities, it also is charged with promoting the CRS industry along with the Office of Space Commercialization of DOC. Thus, to fill a significant knowledge void, NOAA commissioned a RAND Study, which was completed in October 2001, concerning the potential risks faced by the CRS industry. One of the questions RAND set out to answer was to what extent foreign remote sensing systems, which are often heavily subsidized by their foreign governments, create competition for the U.S. CRS industry and how USG policies and regulations either assist or detract from industry's competitive advantages over such foreign systems.[157] In 2001, as its report was completed, RAND listed a least sixteen current and future foreign remote sensing systems that could compete with current and near-term projected systems operated (or to be operated) by the U.S.[158] Countries or international unions operating or planning to operate such systems were Argentina, Australia, Brazil, Canada, Chile, China, the European Space Agency (ESA), France, Germany, India, Israel, Italy, Japan, Russia, South Korea, and Taiwan.[159] Yet, as pointed out by RAND researchers, it is becoming increasing problematic to identify particular remote sensing systems as exclusively belonging to or operated by specific foreign states or consortiums. For example, ImageSat

International was reported by RAND as offering a Satellite Operating Partner (SOP) service, allowing countries where ImageSat ground stations are located to temporarily take control and task ImageSat satellites "within the reception footprint of the (SOPS) ground stations."[160] ImageSat International, formerly known as West Indian Space, is an international company owned by Israeli and a U.S. (California) holding company[161] that owns and operates the Earth Remote Observation Satellite (EROS) series of high-resolution satellites. With the successful launch of the EROS-1 satellite, ImageSat became the second non-governmental-owned CRS entity to operate a high-resolution imaging satellite, following Ikonos-2's launch by the U.S.'s Space Imaging company.[162]

Addressing the economic aspects of CRS and the U.S. industry's competitiveness with foreign earth observation systems, the most recent Presidential policy on CRS (entitled U.S. Commercial Remote Sensing [Space] Policy or CRSSP) specified in broad language the objectives of the USG to promote its domestic CRS industry. To achieve these ends, salient goals were specified in a fact sheet (the only summary document available to the general public on this policy), as follows:

> Enable U.S. industry to compete successfully as a provider of remote sensing space capabilities for foreign governments and foreign commercial users, while ensuing appropriate measures are implemented to protect national security and foreign policy. … Creating a robust U.S. commercial remote sensing industry requires enhancing the international competitiveness of the industry.[163]

Although the policy allowed the U.S. CRS industry to create remote sensing systems that were superior to current or planned foreign commercial systems,[164] it also recognized the national security implications of CRS, should adversaries of the U.S. acquire such systems or the data they provide and, thus, again reaffirmed the USG's ability and right to impose operational controls over U.S.-licensed CRS systems on a case by case basis. Unfortunately, the policy had inconsistent parts; for example, while seemingly promoting the CRS industry by purchasing imagery from U.S. satellite companies to augment the USG's need for military-use imagery, as reflected in Part 5 of the Policy, it continued by stating that the USG would also integrate "foreign commercial remote sensing space capabilities [such as remote sensing imagery and other GIS products],"[165] into the "United States Government imagery and geospatial architectures…"[166] This raises the question, wouldn't integrating foreign systems and products into U.S. architectures dilute U.S. CRS capabilities and competitiveness against these same foreign systems? At least the policy recognized this potential problem and specified that any attempt by the USG to form partnerships with foreign entities regarding remote sensing activities would be subject to "interagency review" and that such foreign-partnership agreements would only be undertaken when national security requirements compel them.[167]

Conventional wisdom usually dictates that DOD and the IC place greater emphasis on national security concerns than on mimicking the perspectives by the CRS industry concerning foreign competition in the CRS arena. Conversely, the U.S. Congress has often been more sympathetic toward U.S. CRS operators and has sought ways to support that sector of the U.S. space industry. Such support was reflected in December 2000, when Congress passed legislation authorizing a bipartisan body, composed of government officials (mostly U.S. Senators and

Congressional representatives) and private citizens, to review the activities of the National Reconnaissance Office (NRO).[168] Part of the report dealt with government licensing of CRS satellites. Perspectives on the issue of foreign competition were noted in the Report of the National Commission for the Review of the National Reconnaissance Office:

> Meanwhile, foreign competitors in the commercial imagery industry enjoy relative freedom from U.S. export and licensing controls. These foreign firms could dominate the global remote sensing market in the 2005 timeframe if their U.S. counterparts are stymied by an ineffective national strategy and a U.S. Government bureaucracy that can not keep pace with the global marketplace. The United States is in danger of losing an opportunity to develop this market, while stimulating foreign investment in it.[169]

To comprehend (or fill a knowledge void concerning) the threat of competition from foreign operators of CRS satellites, it is instructive to survey the current status of foreign high-resolution CRS systems. Back in 2001, a joint RAND/ASPRS Study indicated that the U.S. led the global marketplace with systems capable of providing high-resolution earth observation imagery.[170] In the multispectral-band capabilities of four meters or less and in the panchromatic mode with GSD resolutions of one meter or less, the U.S. had four of the four (100%) listed systems in operation and was projected to have five of eleven systems projected to be launched by 2004.[171]

In October 2004, data on foreign remote sensing satellite systems were updated. According to research conducted by Bill Stoney of Mitretech, the situation began to change. In the overview to an update report, Stoney notes that his guide covers all civilian land remote sensing satellites with resolutions better than 36 meters that were currently in orbit [as of 2004] or planned to be in orbit by 2010.[172] Ignoring all optical systems above one meter panchromatic resolution, Stoney's table indicated five U.S. systems and six foreign systems (in orbit or planned to be placed into orbit by Israel, France, Russia, and Korea), resulting in a drop below the fifty-percent line for U.S. systems.[173]

So, how did the then current data and future projections (showing a decrease in U.S. dominance) compare with the reality as of 2005? Moreover, what can we conclude by extrapolating information on current and future civil or commercial remote sensing satellite systems from that provided by Stoney in 2004? At first glance, the U.S. was still in the lead of nations operating CRS satellites in the high spatial resolution category. Close behind were systems in operation (or planned to be in operation) in the next few years. Such systems were owned or being developed by France, Israel, Russia, India, and South Korea.

Stoney predicted that South Korea, Russia, and India with their Kompsat-2, Resurs DK-1, and Cartosat-2, respectively, would have 1-meter resolution land imaging satellites in orbit between 2004 and 2005.[174] Even though the planned 1-meter resolution electro-optical satellite capabilities offered by those three nations would not have exceeded the current U.S. systems, [175] such as Space Imaging's Ikonos 2 (1-meter), Orbimage's Orbview 3 (1-meter), and DigitalGlobe's QuickBird-2 (0.6-meter), they could still have been considered highly competitive since 1-meter imagery is very high-resolution and sufficient for most commercial purposes. Any capability greater than that would only be of "commercial" value as potential imagery sales to military organizations. Further, should U.S. regulations ever restrict imagery of sensitive areas through shutter control procedures, 1-meter imagery of those areas (offered by states possessing comparable space-based earth-imaging capabilities) would have hurt potential sales of imagery of such areas by U.S. CRS satellite operators.

In the case of Israel and France, it was predicted that they would possess 0.7-meter spatial-resolution capabilities by 2006-2008 and 2008-2009, respectively.[176] France was (and still is) developing two systems (Pleiades-1 and –2) with 0.7-meter sensors and Israel was also developing two systems (EROS B and C series) with 0.7 meter sensors.[177] Although Israel now has a 0.7-meter system in orbit (as of 2007), it should be noted that Israel's Ministry of Defense announced back in 1996 that any industry desiring to enter the CRS business would have to obtain "appropriate permits."[178] The next-generation of French imaging satellites (Pleiades) are part of a constellation of the so-called smallsats developed by France and Italy, with planned contributions from Spain, Austria, Belgium and Sweden.[179] The French Pleiades satellite will provide sub-meter panchromatic and multispectral color imagery in the 2.8 meter range.[180]

While GSD resolution is an important factor in determining CRS competitiveness, other system capabilities, such as off-nadir pivotability (i.e., pointing off vertical axis), swath width, and ground imaging repeat visits, are equally important and possibly not considered or even known by many government policymakers or regulators. Off-nadir pivotability allows earth observation satellites to image (sense) targets of interest that are not directly beneath them, whereas satellites without this capability would only be able to capture such data when its orbit came across such areas of interest within its swath width, which could take weeks or months without this capability. For example, the French Pleiades sensor system will be able to rapidly point from side to side to capture a swath width of 20 km at pivoting speeds reportedly exceeding capabilities of previous French satellites systems.[181] Swath width is important because the larger the width, the more data can be captured on each orbital path (this is most important for medium-resolution systems). Repeat visits (or often called temporal resolution) are the number of days or weeks its takes for a satellite to repeat its same field of view when imaging particular points on earth and this is important for customers who what imagery data in a timely manner, such as domestic and foreign defense organizations that are major customers of CRS imagery.

Utility or applications are also key factors in judging competitiveness of CRS systems in the global marketplace. If imagery data is only being used to develop a single nation's natural resources or map out its terrain and infrastructure, then it would not necessarily block out markets in other countries or regions of the world. For example, South Korea's KOMPSAT-2 (Arirang-2), launched in July 2006 from Russia's Plesetsk Cosmodrome,[182] provides 1-meter panchromatic and 4-meter multispectral color imagery to facilitate the digital mapping of the Korean Peninsula.[183] Previously, Seoul purchased cartographic-enabling imagery and CRS data for other uses from Space Imaging through the latter's Space Imaging Asia partnership/regional affiliate (owned by South Korea's Hyundai Space and Aircraft Company, Ltd.).[184] These factors need to be considered when assessing claims that foreign CRS competitors are or could be affecting the economic viability of the U.S. CRS industry.

Facing potentially stiff competition from foreign CRS imagery providers, U.S. CRS firms have faced significant economic challenges in the global remote sensing marketplace. Although the U.S. CRS industry knows it needs to expand its overseas markets, it has heretofore relied on USG purchases of its imagery data to stay viable in this fiercely competitive environment. Due to financial difficulties and perhaps to create a stronger and more competitive entity in the world market for CRS, the former Space Imaging announced on September 15, 2005 that it had agreed to merge most of its corporate assets with Orbimage. In a press release concerning the impending merger, Space Imaging's CEO made the following optimistic statement: "Together Orbimage and Space Imaging will be a stronger company with a broader global presence."[185] Perhaps inevitable in today's fiercely competitive global market for remote sensing imagery, this move was partially due to Space Imaging's failure to secure future funding from NGA's Next View contract potentially worth 500 million dollars.[186] This points to the fragility and vulnerability of the U.S. CRS industry to financial/economic factors currently impacting the global market for CRS imagery data, something about which U.S. policymakers ought to be (but are not necessarily) aware. Many have argued that the term "commercial remote sensing" is a myth or misnomer because U.S. CRS enterprises rely largely on government contracts to support their operations.

Conclusion

What can we draw from the foregoing research and analyses of competing issues and viewpoints on the high-tech world of space-based earth observation technology? In 1990, Donald MacKenzie argued that missile guidance systems could not be separated from politics. Likewise, and similar to its civil predecessor, Landsat, U.S. CRS satellite systems and programs cannot be separated from politics and organizational/bureaucratic conflicts.

As seen throughout this chapter, varying interests, goals, and priorities associated with U.S. CRS activities are often at the root of such conflicts. Lack of knowledge or understanding of the multiple dimensions of CRS (i.e., political, economic, and technological) also exacerbates existing conflicts of interests and goals for promoting the CRS industry while simultaneously preserving the U.S. national security. The next chapter discusses the institutional roles and social construction aspects of the conflicting viewpoints on CRS policymaking and how knowledge gaps might affect those perspectives.

In the early 1990s, commercial observation satellites sparked heated debates and tensions in the U.S., centered on the issues of national security, global transparency, freedom of information, economic and scientific applications, and international prestige and competition. As discussed in the foregoing sections, the core issues of national security vs. information openness shape many of the opinions, perceptions, and knowledge about how the 21st century eyes in the sky will be used by commercial enterprises. Are the products created by these commercial machines in space potentially detrimental to U.S. national security (should they fall into adversarial hands) or will they benefit society by allowing it to gain unprecedented views of the earth and the activities of its inhabitants? Reflecting on these questions, this chapter has provided a window through which to view the perspectives, debates, conflicts, bureaucratic wrangling, and even moments of cooperation as the USG attempts to pursue the extremely difficult and complicated task of understanding and regulating the activities of the U.S. CRS industry.

CRS covers an extensive knowledge domain (or gaps therein), from what commercial space imagery can reveal or help us understand about the earth to the highly complex legal, policy, and regulatory regimes; to the technical aspects of CRS such as image resolution, shutter restrictions, image interpretation and analysis, and the multidimensional applications of earth observation data; to the challenges we face in the form of foreign remote sensing systems. So far, we have just scratched the surface. To gain additional insights into how CRS control regimens have evolved and will continue to operate in this the 21st century, we need to identify and understand the roles of political, bureaucratic, commercial, and social organizations confronting and attempting to deal with the conflictive issues of CRS policymaking. Such is the subject of the next chapter.

Notes

1. Frank Sietzen, Jr., "Advanced Imagery Raises the Ante: High-resolution imagery from a burgeoning commercial remote sensing industry may pose perplexing policy questions," *Aerospace America* (Sept 2001); http://www.aiaa.org/aerospace/Article.cfm?issuetocid=136&ArchiveIssueID=18 , accessed on September 4, 2005.

2. See Donald MacKenzie, *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance* (Cambridge, MA: The MIT Press, 1990).

3. Ibid, 2.

4. Ibid, 3.

5. Donald MacKenzie, "Missile Accuracy: A Case Study in the Social Processes of Technological Change, in Wiebe E. Bijker, Thomas P. Hughes, and Trevor Pinch, eds., *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (Cambridge, MA: The MIT Press, 1987), 195.

6. See Thomas P. Hughes, *Networks of Power: Electrification in Western Society, 1880-1930* (Baltimore, MD: Johns Hopkins University Press, 1993).

7. Hughes, "The Evolution of Large Technological Systems," in Bijker, Hughes and Pinch, 56, 66, 73-76. According to Hughes, "reverse salients" are bottlenecks, problems, or impediments to efficiency technological evolution and development. This concept can also be applied to the policymaking component of the technological systems of earth imaging satellites.

8. Larry Combest, comments in U.S. Congress, Joint Hearing before the Committee on Science, Space, and Technology and the House Permanent Select Committee on Intelligence. *Commercial Remote Sensing in the Post-Cold War Era,* Washington, DC: U.S. Government Printing Office, 1994), 20.

9. Industrial College of the Armed Forces, National Defense University, Spring 2003 Industry Study Final Report: Space Industry, Washington, DC, 2003; http://www.ndu.edu/ICAF/industry/reports/2003/pdf/2003_SPACE.pdf, accessed September 9, 2007.

10. Kevin M. O'Connell, et. al., *U.S. Commercial Remote Sensing Satellite Industry: An Analysis of Risks* (Santa Monica, CA: RAND, 2001), 89-90.

11. Ann M. Florini and Yahya A. Dehqanzada, "No More Secrets? Policy Implications of Commercial Remote Sensing Satellites," Global Policy Program: Project on Transparency. Working Paper No. 1, July 1999; http://www.ceip.org/files/projects/tcs/remotesensingconf/NoMoreSecrets1.htm, accessed November 27, 2005. Paper was later converted into a published monograph (absent cited phrase),

see Florini and Dehqanzada, *No More Secrets? Policy Implications of Commercial Remote Sensing Satellites* (Washington, DC: Carnegie Endowment for International Peace, 2000).

12. Bob Preston, “Emerging Technology: Emerging Issues for Space Remote Sensing,” Baker John C., Kevin M. O’Connell, and Ray A. Williamson, eds., *Commercial Observation Satellites: At The Leading Edge of Global Transparency* (Santa Monica, CA and Bethesda, MD; RAND and American Society for Photogrammetry and Remote Sensing, 2001), 91-92.

13. Ibid, 94.

14. Donald T. Lauer, An Evaluation of National Policies Governing The United States Civilian Satellite Land Remote Sensing Program, Ph.D. dissertation (Santa Barbara, CA: University of California at Santa Barbara, 1990), 199.

15. Preston, 96.

16. Ibid.

17. Walter S. Scott, letter to the U.S. House of Representatives, Committee on Science, Space, and Technology and the House Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 148.

18. Kevin O’Connell and Greg Hilgenberg, “U.S. Remote Sensing Programs and Policies,” in Baker, O’Connell and Williamson, 147.

19. James A. Lewis, “Remote Sensing Satellites and Presidential Decision Directive-23,” Washington, DC: Center for Strategic and International Studies, March 5, 2002, 1; http://www.csis.org/media/csis/pubs/030502_remotesensing_sats_pdd23.pdf, accessed September 2005.

20. Kevin O’Connell and Beth E. Lachman, “From Space Imagery to Information: Commercial Remote Sensing Market Factors and Trends,” in Baker, O’Connell, and Williamson, 58.

21. White Office, Office of the Press Secretary, Foreign Access to Remote Sensing Space Capabilities, Statement and Fact Sheet [PDD-23] (Washington, DC: March 10, 1994), 1; http://www.fas.org/irp/offDOCs/pdd23-2.htm, accessed October 15, 2005.

22. Lewis.

23. Ibid, 2.

24. Ibid.

25. Ivan Amato, “God’s Eyes for Sale,” *Technology Review*, Vol. 102, No. 2 (March-April 1999), 38.

26. Ibid, 38, 41.

27. John Neer, “Luddite Editor?,” *Technology Review*, Vol. 102, No. 3 (May-June 1999), 15.

28. John Benditt, “Nowhere to Hide,” *Technology Review*, Vol. 102, No. 2 (March-April 1999), 8.

29. J. Todd Black, “Commercial Satellites: Future Threats or Allies?,” *Naval War College Review*, Vol. LII, No. 1 (Winter 1999), p. 101..

30. Florini and Dehqanzada, “The Global Politics of Commercial Observation Satellites,” in Baker, O’Connell, and Williamson, 442.

31. ______, “U.S. Export Constraints Impacting U.S. Content in Alenia Aerospazio Satellite,” *SPACEandTECH*, (August 5, 2002), 1; http://www.spaceandtech.com/digest/sd2000-14/sd2000-14-009.shtml, accessed October 10, 2005.

32. Florini and Dehqanzada, “The Global Politics of Commercial Observation Satellites,” 443, 446.

33. Marcia S. Smith, *U.S. Space Programs: Civilian, Military, and Commercial*, Congressional Research Service Brief for Congress (Washington, DC: Congressional Research Service, Library of Congress, updated February 28, 2005), CRS-6; http://www.au.af.mil/awc/awcgate/CRS/ib92011.pdf, accessed November 28, 2005.

34. Florini and Dehqanzada, “No More Secrets? Policy Implications of Commercial Remote Sensing Satellites,” Global Policy Program: Projects on Transparency, Working Paper No. 1, July 1999; http://www.ceip.org/files/projects/tcs/remotesensingconf/NoMoreSecrets1.htm, accessed June 13, 2004.

35. James H. Frey, Terry A. Straeter, and David W. Thompson, “Testimony to the Joint Hearing of the House Permanent Select Committee On Intelligence and the House Committee On Science and Technology” (Litton Itek Optical Systems, Orbital Sciences Corporation, and GDE Systems Inc., February 9, 1994) p. 9, in U.S. House of Representatives, Committee on Science, Space, and Technology and the House Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 118.

36. Corey G. Hinderstein, “Uses of High-Resolution Commercial Satellite Imagery for Nuclear Nonproliferation” in Michael Jeffee and Joseph Bassi, “High-Resolution Earth Observation from Space: What are Today’s Issues?, Symposium Summary (Washington, DC: Space Policy Institute, George Washington University, and University, MS: Space Law Center, University of Mississippi School of Law, 18 Dec 2001), 4-5; http://www.gw.uedu/~spi/Dec18EO.pdf, accessed November 28, 2005.

37. Michael Krepon, “The New Hierarchy in Space,” in Krepon, et. al., eds, *Commercial Observation Satellites and International Security* (NY: St. Martin’s Press, 1990), 26-29.

38. Peter D. Zimmerman, “Remote Sensing Satellites and Superpower Relations,” in Krepon, Zimmerman, Spector and Umberger, pg. 35-43.

39. John C. Baker and Dana J. Johnson, “Security Implications of Commercial Satellite Imagery,” in Baker, O’Connell, and Williamson, 101.

40. Florini and Dehqanzada, “No More Secrets? Policy Implications of Commercial Remote Sensing Satellites,”13.

41. Baker and Johnson, 120.

42. John C. Baker, “New Users and Established Experts: Bridging the Knowledge Gap in Interpreting Commercial Satellite Imagery,” in Baker, O’Connell, and Williamson, 534-535.

43. David B. Sandalow, “Remote Sensing and Foreign Policy,” remarks delivered at a symposium entitled "Viewing the Earth: The Role of Satellite Earth Observations and Global Monitoring in International Affairs" (Washington, DC: The George Washington University, June 6, 2000); http://www.gwu.edu/~spi/vtespeech.html, accessed September 11, 2005.

44. James A. Lewis, *Preserving America’s Strength in Satellite Technology: A Report of the CSIS Satellite Commission* (Washington, DC: The CSIS Press, April 2002), 23.

45. Larry K. Grundhauser, “Sentinels Rising: Commercial High-Resolution Imagery and Its Implications of US National Security, *Airpower Journal,* Vol. 12. No. 4 (Winter 1998), 68.

46. Taylor Dinerman, “Intelligence Failure at the Networks,” *The Space Review* (April 2004); http://www.thespacereview.com/article/191/1, accessed August 21, 2005.

47. Ibid, 2.

48. Sietzen.

49. Isabelle Sourbes-Verger and Xavier Pasco, “The French Pioneering Approach to Global Transparency,” in Baker, O’Connell, and Williamson, 191-193. Also, see ______, “SPOT-1, -2, -3, -4 Satellite Source/Platform Abstract Document,” (reviewed and revised on July 28, 2998); http://www-eosdis.ornl.gov/source_DOCuments/spot.html, accessed December 3, 2005 (web-document provided by Oak Ridge National Laboratory’s Distributed Active Archive Center and links readers or researchers to NASA-sponsored data centers and other private sources).

50. SPOT-1 was launched in 1986, not 1988, and the U.K. was not a participant in the SPOT program (i.e., in its development, launching, or operations). The confusion or misunderstanding probably stemmed from the fact that the British company-owned Surrey Satellite Technology LTD (SSTL) and the British UoSAT-12 (earlier versions: UoSAT-2) was launched in 1984 and UoSAT-3 was launched in 1990. Research did not uncover any connection of the UoSAT program with the French SPOT satellite program. Launched much later, the UoSAT-12 carried

an onboard sensor capable of 10-m panchromatic resolution (coincidentally the same resolution as SPOT-1). Another possible point of confusion or knowledge gap is that the U.K. happens to be a member of the European Space Agency (ESA) and ESA's Ariane launch vehicle placed SPOT-1 into orbit in 1986 – a very indirect relationship, at best. Further, the British Skynet 4-B military communications satellite was launched on December 11, 1988 on an Ariane rocket, but that system was not a remote sensing satellite with spatial resolution in the meters. For additional details on French and the British programs related to this knowledge gap, see Florini and Dehqanzada, "The Global Politics of Commercial Observations Satellites, in Baker, O'Connell, and Williamson, 444. Also see _____, "SKYNET4;" http://www.fas.org/spp/guide/uk/military/comm/skynet_4.htm, accessed December 3, 2005.

51. Brian Dailey and Edward McGaffigan, "US Commercial Satellite Export Control Policy: A Debate," in Henry Sokolski, ed., *Fighting Proliferation: New Concerns for the Nineties* (Maxwell AFB, AL: Air University Press, Sept. 1996), 171.

52. Ibid, 174.

53. Ibid.

54. Dennis Jones, "Commercial Remote Sensing and National Security," *Crosslink*, Vol. 5, No. 2, 2004; http://www.aero.org/publications/crosslink/summer2004/09.html, accessed June 7, 2006.

55. Ibid.

56. Daily and McGaffigan, 175.

57. Joanne Gabrynowicz, videotaped lectures for course entitled Space Studies 575: Remote Sensing Policy and Law (Grand Forks, ND: University of North Dakota, 2000).

58. Daily and McGaffigan, 175.

59. Dailey and McGaffigan, 177.

60. Ibid.

61. See William E. Stoney, ASPRS Guide to Land Imaging Satellites, September 7, 2006; http://www.asprs.org/news/satellites/ASPRS_DATABASE_090707.pdf, accessed September 15, 2007.

62. Bill Gertz, "Crowding in on the High Ground," *Air Force Magazine Online*, Vol. 80, No. 4 (April 1997); http://www.afa.org/magazine/April1997/0497crowding.asp, accessed August 21, 2005.

63. Mark Brender, "Testimony of Mark Brender, Chairman, Radio-Television News Directors Association Remote Sensing Task Force before the Subcommittee on Space and Aeronautics,

U.S. House of Representatives, Committee on Science," (July 24, 1996); http://www.house.gov/science/mark_brender.htm, accessed August 24, 2005.

64. Ibid.

65. See Baker, O'Connell, and Williams.

66. Vipin Gupta, "New Satellite Images For Sale: The Opportunities and Risks Ahead," *International Security*, Vol. 20 (Summer 1995), 115.

67. Ibid.

68. Ibid.

69. United Nations, Principles relating to the remote sensing of the Earth from space, A/RES/41/65, New York, U.N. General Assembly, December 3, 1986; http://www.un.org/documents/ga/res/41/a41r065.htm, accessed July 29, 2006.

70. Jason Bates, "NIMA Locks Up Ikonos Time Over Afghanistan," (October 15, 2001); http://www.space.com/spacenews/nima_101501.html, accessed July 29, 2006.

71. Gupta, "New Satellite Images For Sale: The Opportunities and Risks Ahead," 116.

72. See Vipin Gupta and Adam Bernstein, "Keeping an Eye on the Islands: Cooperative Remote Monitoring in the South China Sea," in Baker, O'Connell, and Williamson. For Bertein's background, see Appendix D in Baker, O'Connell, and Williamson, 617.

73. Gupta and Bernstein, 355.

74. Grundhauser, 66.

75. Thomas S. Moorman, Jr., "The Explosion of Commercial Space and The Implications for National Security," *Aerospace Power Journal* (Spring 1999), 15. .

76. Black, 101.

77. Ibid.

78. Bill Sweetman, "Spy Satellites: The Next Leap Forward," *Jane's International Defense Review*, Vol. 30 (January 1997), 30.

79. Florini, "The Opening Skies: Third-Party Imaging Satellites and U.S. Security," *International Security*, Vol. 13, No. 2 (Autumn, 1988), 100; citing Patricia Humphlett, "Mediasat: The Use of Remote-Sensing Satellites by News Agencies," *87-70 SPR* (Washington, D.C: Congressional Research Service, January 28, 1987).

80. David L. Willson, “An Army view of neutrality in space: legal options for space negation. (armed conflict and privately-owned satellites),” *Air Force Law Review* (January 1, 2001); http://www.highbeam.com/library/DOCfree.asp?DOCID=1G1:75622166&ctrlInfo=Round18%3AMode18c%3ADOCG%3AResult&ao=, accessed October 26, 2005.

81. Ibid

82. Ibid, 4 (Note 47, citing Black).

83. Lawrence W. Fritz, “High Resolution Commercial Remote Sensing Satellites and Spatial Information Systems,” *IRSPS Highlights*, Vol. 4, No. 2, (June 1, 1999); http://www.isprs.org/publications/highlights/highlights0402/fritz.html, accessed May 21, 2006.

84. Dehqanzada and Florini, *Secrets for Sale: How Commercial Satellite Imagery Will Change the World* (Washington, DC: Carnegie Endowment for International Peace, 2000), 32.

85. O’Connell and Hilgenberg, 139.

86. U.S. Chamber of Commerce, Space Enterprise Council, “National Space Policy Review: Remote Sensing” (no date); http://www.uschamber.com/space/policy/remotesensing2.htm, accessed September 11, 2005.

87. John C. Baker, “Global Transparency: Whither Shutter Controls,” *Imaging Notes*, Vol. 18, No. 1 (Winter 2003); http://www.imagingnotes.com/winter03/global.htm, accessed October 8, 2005.

88. Ibid.

89. Ben Iannotta, “Setting the rules for remote sensing,” *Aerospace America*, Vol. 3, No. 4 (April 1999), 35.

90. Florini and Dehqanzada, *No More Secrets?*, 11.

91. Ibid.

92. Ibid, 12.

93. Ibid.

94. O’Connell, et. al., 80

95. Theresa Hitchens, “Commercial Images: Benefits and Risks,” presentation to a U.S. Army conference entitled “U.S. Space Operations in the International Context” (Washington, DC: Center for Defense Information, March 3, 2004), 1.

96. Ibid.

97. Hampton Stevens, “Government Unlikely to Ban Commercial Space Imagery Sales,” *Defense Information and Electronics Report* (October 12, 2001), reprinted in GlobalSecurity.org; http://www.globalsecurity.org/org/news/2001/011012.attack04.htm, accessed October 8, 2005.

98. O’Connell and Hilgenberg, 154.

99. ______, “Government Unlikely to Ban Commercial Space Imagery Sales.”

100. Ibid.

101. White House, Office of the Press Secretary, “Foreign Access to Remote Sensing Space Capabilities” (Fact Sheet), Washington, DC: March 10, 1994, 3-4.

102. United Nations, “Principles Relating to Remote Sensing of the Earth from Outer Space,” 4; http://ww.licensing.noaa.gov/unrsprinciples.htm, accessed October 9, 2005.

103. White House, Office of the Press Secretary, “Foreign Access to Remote Sensing Space Capabilities” (Fact Sheet).

104. Dan Glickman, comments in U.S. House of Representatives, Committee on Science, Space, and Technology and the House Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 71.

105. Scott Pace, statement in U.S. House of Representatives, Committee on Science, Space, and Technology and the House Permanent Select Committee on Intelligence, Commercial *Remote Sensing in the Post-Cold War Era*, 91.

106. U.S. Congress, *Congressional Record: National Defense Authorization Act for Fiscal Year 1007*, Senate – June 26, 1996 (Washington, DC: U.S. Government Printing Office, 1996), S6924.

107. Matthew Mayer, “Commercial Remote Sensing,” in Industrial College of the Armed Forces, National Defense University, Spring 2003 Industry Study: Final Report – Space Industry, 19, 22.

108. Ibid.

109. Ibid.

110. Memorandum of Understanding [MOU] Among the Departments of State, Defense, Commerce, Interior and the Intelligence Community Concerning the Licensing of Private Remote Sensing Satellite Systems, 2-3. Also see Ernest Miller, “Features: US Wields $ Not Law to Censor Satellites,” *LawMeme, online research journal* (New Haven: CN: Yale University Law School, 20 Oct 2001), 5; http://research.yal.edu/lawmeme/modules.php?name=News&file+article&side+114, accessed October 8, 2005.

111. Ibid (MOU), 3.

112. David Corn, “Their Spy in the Sky,” *The Nation* (November 26, 2001); http://www.thenation.com/DOC/20011126/corn, accessed 8 October 2005.

113. Industrial College of the Armed Forces, National Defense University, Spring 2003 Industry Study: Final Report – Space Industry.

114. Aerospace Industries Association, “Current Reforms to Support the U.S. Satellite Remote Sensing Industry Base” (posted July 1, 2004), 1; http://www.aia-aerospace.org/pdg/policy_reforms_to_support_the_us.pdf, accessed January 18, 2007.

115. U.S. Congress, Office of Technology Assessment, *Civilian Satellite Remote Sensing: A Strategic Approach*, *OTA-ISS-607* (Washington, DC: U.S. Government Printing Office, September 1994), 101.

116. John C. Baker, “Global Competition Creates Cooperative Opportunities,” *Imaging Notes* (Jan-Feb 2002); http://www.imagingnotes.com/janbeb02/global.htm, accessed August 29, 2005.

117. Ibid.

118. O’Connell and Hilgenberg, 146-147.

119. Aerospace Industries Association, “Policy Reforms to Support the U.S. Satellite Remote Sensing Industry Base,” (report posted on July 1, 2004); http://www.aia-aeropsace.org/pdf/policy_reforms_to_support_the_us.pdf, accessed January 18, 2007.

120. Ibid.

121. John R. Copple, letter to Senator Bill Frist, U.S. Senate, Senate Commerce Subcommittee on Science, Technology, and Space (hearings); http://commerce.senate.gov/hearings/35cop.pdf, accessed October 29, 2005.

122. Ibid, 3

123. Ibid.

124. Ibid.

125. Ibid.

126. Ibid.

127. Keith Calhoun-Senghor, statement in U.S. House of Representatives, Committee on Science, Subcommittee on Space and Aeronautics, “The Commercial Space Act of 1997, Part I:

Commercial Remote Sensing (hearing), May 21, 1997, 38; http://commDOCs.house.gov/committees/science/hsy141160.000/hsy141160_0.htm, accessed October 30, 2005.

128. Jeffrey K. Harris, statement in U.S. House of Representatives, Committee on Science, Subcommittee on Space and Aeronautics, "The Commercial Space Act of 1997, Part I: Commercial Remote Sensing (hearing), 12; http://commDOCs.house.gov/committees/science/hsy141160.000/hsy141160_0.htm, accessed October 30, 2005.

129. Gupta, "New Satellite Images for Sale," 98 (page span 94-125). Also see ______, "Policy Development on Sale of High-Resolution Satellite Imagery;" http://www.llnl.gov/csts/publications/gupta/pd.html#russia, accessed October 31, 2005.

130. Deborah Foster, "The Indian Space Program, in Baker, O'Connell, and Williamson, 248.

131. Stoney, "Foreign Land Imaging Satellite Programs" in Advisory Committee for Commercial Remote Sensing (ACCRES), National Oceanic and Atmospheric Administration (NOAA), Meeting Summary [2nd Meeting], January 14, 2003, 5; http://www.accres.noaa.gov/Draft-Meeting-Minutes.doc, accessed September 14, 2007. For a current listing of international high-resolution CRS systems, see Appendix I of this dissertation

132. Timothy Stryker, "Responses to NOAA's Request for Information on Its Licensing Programs," summary of comments in Advisory Committee on Commercial Remote Sensing (ACCRES), National Oceanic and Atmospheric Administration (NOAA), Draft Meeting Summary [4th Meeting], December 11, 2003, 3; http://www.accres.noaa.gov/Meeting_Report_Dec11.pdf, accessed September 14, 2007.

133. Susan Moran, statement in U.S. House of Representatives, *The Commercial Act of 1997, Part 1: Commercial Remote Sensing*, Hearings (May 21, 1997), 7; http://commDOCs.house.gov/committees/science/hsy141160.000/hsy141160_0htm, accessed October 31, 2005.

134. John Townshend, statement in U.S. House of Representatives, *The Commercial Act of 1997, Part 1: Commercial Remote Sensing*, Hearings (May 21, 1997), 9.

135. George J. Tahu, "Russian Remote Sensing Programs and Policies," in Baker, O'Connell, and Williamson, 166.

136. Florini, "The Opening Skies: Third-Party Imaging Satellites and U.S. Security," International Security, Vol. 13 (Fall 1998), 94.

137. Dehqanzada and Florini, *Secrets for Sale: How Commercial Satellite Imagery Will Change the World*, 3.

138. Using percentages to describe change ratios can be confusing. For example, going from 2 square meters to 1 square meter might seem like a 100-percent change or improvement, but it is actually a 300-percent improvement (1x change = 0 percent, 2x change = 100 percent, 3x change = 200 percent and 4x change = 300 percent improvement). Improvement in resolution capabilities actually works in reverse (i.e., going from larger square-meter resolvability to smaller square-meter resolvability). While there is a 400-percent change from a 2 square meter pixel to a 1-meter square pixel, the percentage of increase in resolution is actually 300 percent. Using another example (i.e., in monetary terms), if one had one dollar today and two dollars tomorrow, that would be an increase of 100 percent, but a doubling or change factor of 2).

139. Harris, 32.

140. Dana Rohrabacher, comments in U.S. House of Representatives, Committee on Science, Subcommittee on Space and Aeronautics, The Commercial Space Act of 1997, Part III: Commercial Remote Sensing, Hearing; June 4, 1997, 89-90; http://commDOCs.house.gov/committees/science/hsy141160.000/hsy141160_0.htm, accessed October 31, 2005.

141. Ibid.

142. Ibid, 90.

143. Scott Pace, statement in ______, "Emerging Intellectual Property Rights and Other Policy Issues with the Commercialization of Remote Sensing," notes taken during a CRESS Seminar (College Park, MD: University of Maryland, Department of Geography, April 29, 1988), 2; http://www.geog.umd.edu/cress/s-pace.htm, accessed October 31, 2005.

144. Scott Pace, statement in U.S. House of Representatives, Committee on Science, Subcommittee on Basic Research, Using Commercial Data Sources in the Earth Science Enterprise (Hearing), September 28, 1998; http://www.house.gov/science/pace_09-28.htm, accessed October 31, 2005.

145. National Research Council, Space Studies Board, *Toward New Partnerships In Remote Sensing: Government, the Private Sector, and Earth Science Research* (Washington, DC: The National Academies Press, 2002), viii.

146. Ibid, 44.

147. The Orbview 2 (SeaStar) satellite is an ocean-color monitoring satellite owned and operated by the CRS firm, Orbview, of Dulles, Virginia (subsidiary of Orbital Sciences Corp.) and carries a NASA multispectral SeaWiFS sensor. It provides 1.13 km multispectral resolution in 8 spectral bands. For more details on this hybrid civil/commercial imaging system see Mel Whalen, "The SeaWiFS Satellite," (Washington, DC: Galluadet University); http://clerccenter.gallaudet.edu/Mssd/MSSD-Science/satellites/seawiffy.html, accessed October 31, 2005. Also Jet Propulsion Laboratory, National Aeronautics and Space Administration,

"SeaWiFS. SeaStar" (Pasadena, CA: NASA, Jet Propulsion Laboratory); http://samadhi.jpl.nasa.gov/msl/QuickLooks/seastarQL.html, accessed October 31, 2005.

148. Orbimage, "ORBIMAGE Finalizes Agreement with NOAA to Provide Image Data for Environmental Research" (Dulles, VA: Orbimage, October 28, 2005); http://www.orbimage.com/news/releases/10-28-05.html, accessed October 31, 2005.

149. National Research Council, Space Studies Board, *Toward New Partnerships In Remote Sensing: Government, the Private Sector, and Earth Science Research*, 23.

150. ______, untitled document from a collaborative workshop of NASA personnel held in La Jolla, CA (Avninda Sharma, India: Innovation Labs LLC, October 8, 2003); http://www.innovationlabs.com/dryden/r2_introduction.html, accessed October 31, 2005. Also see ______, "IKONOS Data Guide" (Durham, NH: University of New Hampshire, website, last updated July 7, 2003); http://eos-webster.sr.unh.edu/data_guides/ikonos_dg.jsp, accessed October 31, 2005.

151. Scott Pace, et. al. *The Earth Below: Purchasing Science Data and the Role of Public-Private Partnerships* (Santa Monica, CA: RAND, 2000), 50.

152. Ibid.

153. Ibid.

154. Ibid, 77.

155. Ibid.

156. Ibid, 87-88.

157. O'Connell, et. al., 8.

158. Ibid (Figure 4.1), 58. According to the RAND study cited, the countries and systems nomenclatures were: Canada (Radarsat 1 &2), EAS (ERS series, Envisat), Italy (COSMOS, Skymed series), France (SPOT series and Heilos 1 &2), Germany (RapidEye, SAR-Lupe, and TerraSAR), Israel (EROS A&B series), Russia (Resurs-02, ALMAZ), Korea (KOMPSAT/Arirang 1 and 2, Kitsat series), Japan (ADEOS, ALOS, IGS), Taiwan (RocSat 1&2), Australia (Aries), India (IRS series, Cartosat), China and Brazil [joint venture] (CBERS series), Brazil [only] (MECB series), Argentina (SAC-C), and Chile (FA Sat-Alfa). Of course, not all of these systems are high-resolution imaging systems with resolutions capabilities of 2 meters or less.

159. Ibid, 58 (minus explanatory comments).

160. Ibid, 63-64. Also see ______, "Satellite Operating Partner Program," ImageSat International;

http://www.imagesatintl.com/?catid={C430687B-FB8B-4CCC-B3B9-EDC528B0D044, accessed August 27, 2005.

161. ______, "West Indian Space Changes Name to ImageSat, Announces Product Offerings," Andrews Space and Technology; http://www.spaceandtech.com/digest/sd2000-22/sd2000-22-007.shtml, accessed August 27, 2005.

162. See ImageSat webpage on the EROS-B program at: http://www.imagesatintl.com/default.asp?catid={967F2328-D51E-4AC9-929E-FF6FD434B414}, accessed on August 27, 2005.

163. White House, "U.S. Commercial Remote Sensing Policy: Fact Sheet," April 25, 2003; http://fas.org/irp/offDOCs/nspd/remsens.html, accessed November 30, 2005.

164. Ibid.

165. Ibid.

166. Ibid.

167. Ibid.

168. See National Commission for the Review of the National Reconnaissance Office, Report of the National Commission for the Review of the National Reconnaissance Office: Preparing the NRO for the Future; http://www.fas.org/irp/nro/commission/prepare.htm, accessed November 30, 2005.

169. Ibid.

170. Stoney, "Appendix B, The Past, Present and Future of the Medium- and High-Resolution Satellite World (Table A-1 – Data Characteristics of Current and Planned Land Imaging Satellites)," in Baker, O'Connell, and Ray A. Williamson, 579-587.

171. Ibid, 584.

172. Stoney, "ASPRS Guide To Land Imaging Satellites," November 8, 2004, 3; http://www.asprs.org/news/satellites/ASPRS_DATABASE_110804.pdf, accessed June 1, 2007.

173. Ibid, 8.

174. Ibid.

175. Israel's EROS-B satellite reportedly has a GSD resolution of 0.7 in the panchromatic mode and thus slightly exceeds the U.S.'s Ikonos-2 satellite, which provides imagery at 0.82 meters GSD resolution (at nadir). Although India's Cartosat-2 reportedly provides imagery at slightly better than 1 meter, it is unknown as to how much better. Assuming it is not better than 0.6

meters, the most advanced imaging satellites currently operated by Israel, India, and Russia do not exceed the spatial resolution capabilities (on panchromatic mode) offered by the U.S.'s QuickBird satellite, which is 0.6 meter GSD. See technical details at the eoPortal's [Directory of] Earth Observation Resources; http://directory.eoportal.org/res_p1_Earthobservation.html, accessed May 18, 2007.

176. Ibid, 7-9.

177. Ibid.

178. Gerald M. Steinberg, "Commercial Observation Satellites in the Middle East and the Persian Gulf," in Baker, O'Connell, and Williamson, 237.

179. Peter B. de Selding, "Weight Gain Could Boost Cost of Cosmo-Skymed Craft," *Space News* (February 2, 2004); http://www.space.com/spacenews/archive04/cosmoarch_020204.html, accessed October 10, 2005.

180. Patrice Damilano, "Pleiades High Resolution Satellite: a Solution for Military and Civilian Needs in Metric-Class Optical Observations," SSCO1-I-5; paper presented August 13, 2001 at the 15th Annual AIAA/Utah State University Conference on Small Satellites, 1-2; http://www.aria.seas.ustl.edu/SC01/papers/1-5.pdf, accessed October 10, 2000.

181. de Selding, 1.

182. Tae-gyu Kim, "KOREA: Korea joins world's satellite powers," *Korea Times* (August 22, 2006; http://www.asiamedia.ucla.edu/article.asp?parentid=51389, accessed May 18, 2007.

183. ______, "Arirang-2 Satellite to Launch This Year," *KBS Global* (May 31, 2005); http://english.kbs.co.kr/news/newsview_sub.php?menu=6&key=2005053111, accessed October 10, 2005.

184. ______. "Space Imaging Asia Formed in Seoul: Hyundai Space & Aircraft Co. Becomes Regional Affiliate of Space Imaging," *Business Wire* (October 28, 1994); http://www.highbeam.com/library/DOCfree.asp?DOCID=1G1:56972611&ctrlInfo=Round18%3AMode18c%3ADOCG%3AResult&ao=, accessed on October 10, 2005.

185. Space Imaging, "ORBIMAGE Agreement to Purchase Assets of Space Imaging" (press release), September 16, 2005; http://www.spaceimaging.com/newsroom/2005_ceoStatement.htm, accessed October 10, 2005.

186. Roger Fillion, "Shakeout: Too many companies for too few deals jolt satellite-imaging industry," *Rocky Mountain News* (August 8, 2005); http://www.rockymountainnews.com/drmn/technology/article/0,1299,DRMN_49_3985222,00.html, accessed October 10, 2005.

Chapter 3

Socio-Political Construction of Commercial Remote Sensing

Introduction

As a controversial high technology, CRS has significant impacts on society, particularly its political and commercial sectors. While the previous chapter discussed the issues this technology has created for U.S. policymakers, this chapter focuses on the organizations and institutions that are affected by CRS technology and how those organizations and institutions in turn influence the development, utilization, and control of that technology. This chapter begins by connecting or relating STS themes and frameworks, particularly those of Donald MacKenzie, to my study and analysis of intergovernmental and intersector relationships as they influence the evolution of U.S. CRS legal and regulatory regimes and efforts to reach consensus and accommodation on how to structure such regimes. STS themes related to the politics of CRS include institutional roles, the social construction of CRS technology, social worlds theories, and knowledge domains or gaps therein.

Social construction of technology (SCOT) theories argue that various technologies and their uses are shaped by relevant social groups, which in the case of CRS would be key actors within the CRS policymaking community, such as Congress, the White House, key executive branch departments and agencies in a primary role and the CRS industry, scientific community, media organizations, and other CRS imagery users in a supporting or advocacy role. How these social groups shape CRS depends on the perspectives, interests, goals, beliefs, missions, organizational culture, and synoptic knowledge and comprehension (of CRS) of each of these groups. If one group (e.g., consisting of key government officials) views CRS as promoting global transparency and solving domestic and international problems, that group would likely lobby Congress and the administration for passage and implementation of favorable CRS laws and policies that facilitate the maximum capabilities and uses of CRS space systems. Conversely, if another powerful group of relevant socio-political actors views uninhibited CRS as intruding on their once-held monopoly over geo-surveillance systems or unintentionally serving the needs of groups or nations bent on threatening or damaging U.S. national interest or those of its allies (such as terrorists, narco-traffickers, or even warring states), they will attempt to socially construct CRS technology so that it possess extremely limited capabilities (e.g., imaging resolution not exceeding certain thresholds) or operates under restricted conditions (e.g., shutter control or degradation of imagery over specific areas such as Israel).

Differing beliefs, goals, and/or viewpoints or social constructions of CRS involve a range of incompatibilities, many of which are based on the CRS-related knowledge of each group and knowledge gaps between such groups. For example, if one group or organization has significant knowledge of the military use of CRS imagery but little to no knowledge of its peaceful (e.g., scientific, social, economic) uses, it would be natural to expect that such group or organization would view CRS as a technology with intrinsic dangers and risks (if used by less than benevolent states or actors). On the other hand, if a group has significant knowledge of the peaceful applications of CRS technology (i.e., applications in the fields of agriculture, environmental monitoring and research, forestry, mining, mapping, urban planning, etc.) but insufficient knowledge of how CRS imagery can be used to threaten U.S. national security or foreign policy interests, then such group would naturally lean toward a permissive, openness view of CRS. Whichever group is the strongest and most dominant in the CRS policymaking arena will have the most influence over how CRS systems are to be developed and operated on a national and global scale. When it comes to construction of CRS systems, industry (particularly satellite manufacturers) could be seen as having substantial influence over Congressional actions in this arena. Yet, even with their financial resources and influence, they have to compete with powerful forces (i.e., national security institutions) when attempting to influence the USG bureaucracy that ultimately crafts and implements CRS policies and regulations.

In the context of CRS, social worlds involve groups that are committed to various viewpoints on how best to deal with the emerging technology of CRS and its applications. One such social group consists of the CRS industry and those that support its efforts to widely promote the use of commercial imagery in the domestic and international marketplace. They are generally characterized as being on the transparency and openness side of the liberal-conservative spectrum of U.S. CRS policy. Their views tend to gravitate toward unfettered use of earth observation technology. On the other end of the social worlds spectrum, one finds ardent national security advocates generally within DOD, DOS, the IC, and among others casting a cautionary view on the privatization or commercialization of remote sensing technology (due to its inherent dual-use aspects).

In the middle, we find social worlds that attempt to cross boundaries and link the interests of what one could call "polarized" social worlds in CRS policymaking. Such groups consist of DOC (OSC and NOAA), DOI, Congress, and to some extent, the White House (OSTP, NSTC, etc.). DOC plays a unique role in the construction of CRS because it is tasked with both promoting and regulating CRS activities (through NOAA). Yet even within the domain of CRS policymaking, these social worlds or institutions can have diverse sub-worlds. For example, DOD and DOS have hardliner national security proponents who view CRS as a potential threat to U.S. interests (should CRS imagery fall into the wrong hands) and thus wish to restrict it as much as possible, whereas such organizations may also have ardent supporters of quite limited restrictions on CRS because they view CRS imagery as supporting their institutional roles associated with military operations, intelligence gathering, and foreign policy actions related to humanitarian, peacekeeping, and environmental concerns.

The above themes (knowledge voids, social construction, social worlds) are related to each other. CRS social worlds are created and shaped by (and often shape) institutional roles and missions and knowledge of CRS technology and applications. They participate in the social construction process by imparting their social world's viewpoints and knowledge to other related CRS social worlds with an aim toward convincing those other social worlds to adopt their policy points of view (a process in STS called "translation"). Much of this interaction will be detailed in various sections below on the relevant socio-political actors in CRS.

Institutional roles often dictate what part of the CRS knowledge terrain will be occupied (i.e., focus on or comprehension of the technical, military, economic, social, political, international, or scientific aspects of CRS). DOS focuses on the political and international aspects and thus would have a wealth of knowledge in those areas. DOD focuses on the military and intelligence implications of CRS technology, and thus would be most knowledgeable about those areas. The CRS industry is mostly interested in the economic aspects (they need to be profitable) and thus would be most knowledgeable about how to make CRS economically viable and robust. The scientific community tends to focus on CRS imagery as a research tool and would be the most knowledgeable and the most supportive of the scientific role of U.S. CRS systems. Thus, when constructing CRS technology, it is easier to do so based on what one knows vs. what one doesn't know. Of course, all of these themes create a very complicated matrix of interrelated factors that requires significant comprehension of the multidimensional aspects of CRS.

To gain greater insights into the organizational mindsets and culture of CRS-related entities, this chapter details the key players, such as the U.S. CRS industry, USG agencies and organizations, and other social actors on the CRS scene – all with the intent to identify gaps in understanding the complex nature of CRS and related policy issues. As stated in the introductory chapter of this dissertation, the subthesis of this project is that knowledge gaps are created by the complexity of CRS technology and applications and associated, legal, policy, and regulatory issues and that such knowledge gaps potentially shape perspectives on how CRS laws, policies, and regulations should be crafted, refined, and ultimately implemented.

Integrating STS Themes

Technologies, especially large, complex, technical systems, are not always simple tools that can be improved without wider consequences. Changes in technology go hand-in-hand with changes, small and large, in the preconditions of their use, in the ways they are used, in who uses them, and the reasons for their use.

– Donald MacKenzie (1990)[1]

STS scholars have been highly interested in how particular technologies are constructed. The quintessential book on this aspect of STS is *The Social Construction of Technological Systems*, edited by STS scholars Wiebe Bijker, Thomas Hughes, and Trevor Pinch. Their social construction of technology (SCOT) themes focused on how technologies are designed and built (e.g. "technological frames" by Bijker and "large technological systems" by Hughes) and how they are used (e.g., sociopolitical framework used by MacKenzie).

In 1990, Donald MacKenzie wrote about the social construction of nuclear missile guidance systems and conflicting political and technical strategies that determined their creation, development, and ultimate use. A few years earlier, MacKenzie wrote a paper on missile accuracy, which was reworked and included in his 1990 book, and in that earlier work he emphasized the institutional structure of a technological system as possibly being the most important aspect of technological development.[2] Therein, MacKenzie noted: "…technological development cannot satisfactorily be treated in isolation from organizational, political, and economic matters."[3] Following his example, this chapter discusses in some detail the organizational, cultural, and socio-political dimensions of U.S. CRS policymaking, Essentially, MacKenzie wanted to understand the technology of missile guidance as "a historical product and social creation"[4] and discovered through his research that U.S. missile guidance technology was the "product of a complex process of conflict and collaboration between a range of social actors…"[5] Similarly, U.S. CRS policymaking evolves through conflicts and collaboration among key players and organizations, which will be discussed at length in this chapter. Using his chosen technology as an example, MacKenzie showed how missile guidance systems shaped (and was shaped by) politics. His research model includes technology-shaping actors (social groups) such as the technologists, the military, and politicians.[6] All had a stake in the development of missile guidance. Similarly, but focusing more on the utilization aspect than the creation and development process of remote sensing technology, this dissertation, and particularly this chapter, provides insights into the socio-political construction of U.S. CRS technology. Even though many of the CRS systems are similar in their engineering and technological aspects (i.e., how they are built and function), I am more interested in this case study in how such systems are actually used (i.e., for political, economic, scientific, and humanitarian purposes, etc.) and how such uses are politically constructed. For example, Congress politically constructs CRS to bolster the U.S. space industrial base, contribute to the domestic economy (especially when CRS technology firms are located in individual Congressional districts), to satisfy various CRS user groups, and, most importantly, to develop a supplementary system of earth observation satellites that complement programs such as the civil Landsat and NASA's Earth Observing Systems (EOS).[7] DOD and, to some extent, DOS views CRS as a potential security risk but also sees the value of CRS imagery in supporting their departmental missions. NOAA and NASA view CRS as a scientific tool (augmenting Landsat, EOS, and weather/ocean-observation satellites) and, thus, have a special ear for the scientific and environmental communities. NOAA, of course, plays a complicated role in the social construction process by simultaneously serving as an advocate and supporter of CRS, while simultaneously acting as its chief regulator.

Finally, industry politically constructs CRS by providing advice to Congress and the executive branch concerning CRS legislative, policy, and regulatory matters; interfacing with DOD (specifically NGA) and other federal, state, and local governments to secure imagery purchasing contracts; and being in a position to develop and operate CRS satellites that ultimately influence and shape U.S. CRS policies and regulations. Essentially, industry constructs CRS by endeavoring to make it a profitable enterprise and creating a position of U.S. leadership in the high-tech world of spacebased earth observation technology.

The objective of this chapter is to determine who the actors are in this socio-political construction process. For example, Congress creates CRS laws, the White House formulates CRS policies, and executive branch agencies craft the CRS rules and regulations. Other participants in all of these processes are the U.S. CRS industry and users of remote sensing imagery such as USG agencies, academia and the scientific community, the media, NGOs, imagery activist groups, and policy institutions, to name a few.

Not only is the technology of remote sensing complex, the technology operates within a highly complicated socio-political environment composed of a myriad of actors and organizations. Understanding the makeup of and relationships between these actors and organizations is key to understanding how best to regulate the operations of the technology.

Moreover, the players on the CRS stage have heterogeneous backgrounds and come from divergent social, economic, and political worlds and institutional cultures, which often dictate or shape their perceptions of what is or ought to be the ideal policy and regulatory framework within which U.S. CRS systems operate. A similar concept to these divergent worlds is the concept of "social worlds" [8] as portrayed by science studies scholars Susan Star and James Griesemer. Writing in 1999, they argued that science involves heterogeneous groups of actors and thus requires intergroup cooperation and collaboration to effectuate scientific discoveries, explanations, and progress.[9] Likewise, as a technological system, CRS involves disparate groups within the U.S. CRS policymaking arena, all requiring a semblance of cooperation to craft and execute U.S. CRS laws, policies, and regulations.

Star and Griesemer also recognize that intergroup knowledge voids can exist and they advance the concept of "translation" (e.g., explaining the meaning and value of one's point) as a prerequisite for intergroup cooperation and collaboration. Star and Griesemer's explanation of "social worlds" were instructive for this chapter, since their "social worlds" are similar to those inhabited by the plethora of participants in the politics of U.S. CRS. Star and Griesemer address actors in their shaping of scientific endeavors, an example very similar to the U.S. CRS policymaking arena, except the former groups dealt with biology and the latter groups deal with space imaging and related political dynamics. According to Star and Griesemer, the participants "…translate, negotiate, triangulate, and simplify in order to work together."[10] I detected a similar process unfold as I identified and analyzed the relationship between and among the various actors involved in shaping the U.S. CRS environment. Put differently, in order for an enterprise to work, it usually needs to seek cooperation (positive inputs) and a common language from various actors essential for its viability and development – "intersectional work" or "intersectional social worlds" as Star and Griesemer put it.[11] According to them, "varying degrees of coherence obtain both at different stages of the enterprise and from different points of view."[12] CRS stakeholders engage in social world translations to impart or simplify their knowledge domains to other stakeholders in a variety of ways and forums. Much of these translation efforts go on behind the scenes (non-public forums) with CRS industry representatives meeting or communicating with key U.S. CRS policymakers and regulators during and after the crafting of CRS laws, policies, and regulations. Other mechanisms for translation efforts involve participating in advisory committee meetings, CRS symposia, and other specialty conferences involving CRS issues.

When using these venues, each side of CRS policy debates (closed vs. open information/ transparency regimes) attempts to explicate their viewpoints on what constitutes the best CRS policies for national security, economic, and scientific purposes; how CRS is valuable to society and to the government; and how CRS imagery can present a threat to U.S. national security and foreign policy objectives if used by bad actors. I have witnessed these translation sessions in numerous advisory committee meetings and CRS conferences. Briefing slides used as a translation prop are sometimes simplistic and educational to those with knowledge voids on the subject, but they can also be very complex as if to impress attendees of CRS meetings or conferences by showing how educated or informed the presenters are (which could be interpreted as attempts to "black box" the complexity of stakeholders' knowledge domains).

Attempts are made through these translation sessions to negotiate policy issues and enlist key actors (particularly on the government side) to one's perspectives, thus hopefully closing CRS perception gaps. Techniques used in such translation actions include providing abundant amounts of information to fill knowledge gaps or using persuasive arguments to sway others to one's own policy positions.

Even though translation attempts are made to enlist CRS stakeholders to one's side or viewpoint, such efforts are problematic in the direction from the CRS industry to the UGS policy institutions or agencies that execute CRS laws and policies. USG representatives that attend CRS meetings and conferences are often not the highest decision makers in their organizations and are challenged in conveying the perspectives of industry to their higher-level management. In other words we face the potential of translations being lost through the multilevel layers of government bureaucracy.

Essentially, Star and Griesemer describe varying degrees of interpretation coherence and divergence during various stages of a scientific project. In a somewhat similar vein, differing degrees of interpretation of the meaning of CRS have also been manifested in the process of CRS policymaking involving multiple actors and organizations (as described below). The complex matrix of relationships between these actors and organizations will be discussed and analyzed at length in the remainder of this chapter.

Commercial/Public Stakeholders (Industry vs. Government Policymakers and Regulators)

Commercial Sector

To examine and appreciate the interactions and relationships between key stakeholders in the U.S. CRS arena, I begin with a survey of the U.S. CRS industry. Until very recently, relationships between the U.S. CRS industry and the USG (which acts as both patron and regulator of the former) have not been extremely amicable. Of course, the CRS industry (at least the satellite operations sector of that industry) has often been in an awkward position since it cannot currently exist without government support or approval, given the need to market much of its products to the government and based on the obligations to acquire licenses from the government to operate earth observation satellites. Although such licenses are issued by NOAA (an arm of DOC, which is an advocate of the imaging satellite industry), license requests are reviewed by other USG agencies such as DOD, the IC, DOS, DOI, and others as needed. The multitude of government organizations involved in this process makes it difficult to achieve consensus on hot CRS policy issues.

Even since the mid-1990s when PDD-23 (now replaced by the current administration's policy on CRS) began to dictate the U.S. CRS licensing environment for industry, CRS firms have been dismayed at what they view as illogical, impractical, and potentially harmful policies and regulations concerning their space enterprises. However, they have had little choice but to reluctantly go along with such policies. Even by 1999, U.S. CRS industry officials were still reticent about challenging the government on shutter control issues. According to Joe Dodd, Vice President for Government Programs at Orbimage (now GeoEye), there appeared to be a resignation that complaints about USG policies governing the U.S. CRS industry would fall on deaf ears.[13]

During the 1990s, there were some components of the CRS satellite industry that were very critical of government policies and regulations concerning their future satellite operations. According to Winn Hardin, writing in a May 1999 International Optical Engineering Community report (called the *EO report*), numerous industry experts viewed U.S. regulations as "not only impossible, but a short-sighted response that could result in the U.S. following, instead of leading, a multibillion dollar global market."[14] Yet, the nascent CRS industry needed to walk a tightrope, since they needed legislative, policy, and regulatory support to even get into (much less remain in) business, and since the USG would be a primary customer of U.S. CRS products.

During my research for this dissertation, it was noted that nothing extensive has been written about the (formerly) "Big Three" U.S. CRS firms – DigitalGlobe, Orbimage and Space Imaging. In October 2001, a RAND study prepared for DOC devoted about a paragraph to each of these commercial organizations, along with three other firms that received licenses but have yet to launch any earth imaging systems.[15] In the same year, RAND and ASPRS teamed up to produce a report (published as a book) entitled *Commercial Observation Satellites: At the Leading Edge of Global Transparency*.[16] That monumental work included contributions from thirty-one leading U.S. and international experts in the field of CRS policies and applications. Still, that work only devoted only about a page or two in describing each of these U.S. CRS firms, which pioneered the current commercial earth observation industry in America. Thus, the following subsection provides more details about these three CRS pioneers and their relationships with USG policymakers and regulators.

<u>*Space Imaging*</u>

The former Space Imaging, based in Thornton, Colorado, is acknowledged as the first U.S. CRS firm to have successfully launched and operated a high-resolution (1-meter GSD) earth observation satellite – Ikonos 2. Space Imaging International was established in 1994 under the investment aegis of Lockheed Martin Corporation and Raytheon E-Systems Company. It later became an independent company but retained partnerships with Lockheed, E-Systems and Mitsubishi. Space Imaging received its first license from DOC on April 22, 1994 to launch and operate a CRS system called Ikonos.[17] In that same year, Space Imaging broke off from Lockheed and expanded its capabilities by purchasing the Earth Observation Satellite Company (EOSAT), former operator of the Landsat satellite system, in 1996.

Space Imaging has a short but interesting history in the world of CRS. On February 23, 1995, the company announced a business alliance with Eastman Kodak for the latter to build the digital camera for Space Imaging's Ikonos satellites, which were still in development but planned to be launched in 1997 (later pushed to 1999).[18] The Ikonos satellites were originally to be dubbed Commercial Remote Sensing Satellite systems or (CRSS). Space Imaging later moved from Sunnyvale, California to Thornton, Colorado on 15 May 1995.[19] On November 16, 1997, Space Imaging partnered with UAE investors to form Dubai Space Imaging, to provide high-resolution imagery of IRS-1C and 1-D imagery to Middle-Eastern customers.[20]

Space Imaging had some traumatic experiences in attempting to be the first U.S. high-resolution CRS satellite company. On April 28, 1999, Space Imaging's Ikonos-1 satellite failed to reach orbit due to a Lockheed Martin Athena II rocket not attaining sufficient velocity during the launch phase. Space Imaging quickly recovered, though, by successfully launching its Ikonos-2 satellite on September 24, 1999 (some 5 years after the company was formed). Still operating, Ikonos-2 carries a 1-meter panchromatic and 4-meter multispectral imaging sensor.

In 2000, the company began aggressive marketing its CRS services internationally, setting up affiliates and distributorships of its imagery in Turkey (in December 2000), Germany (with the establishment of European Space Imagery in Munich, Germany) and Australia (through Raytheon Australia) to distribute imagery throughout Australia and New Zealand. As of 2001, Space Imaging still maintained a limited relationship with Lockheed Martin, but has also partnered with numerous international firms such as Thailand's Loxey Public Co., Ltd.; South Korea's Hyundai Space and Aircraft; Japan's Mitsubishi Corp, Singapore's Van Der Horst Ltd., and the Swedish firm Space Corp.[21] With regional alliances with other firms in the Middle East, Latin America, and Europe, Space Imaging had become a truly global (transnational) company. Such ties most likely gave rise to significant national security concerns by the USG.

During its short history, Space Imaging has had a significant turnover of key executives. In 1995, John Neer, first CEO and founder of Space Imaging, was replaced by John Copple and Neer became Space Imaging's chief technical officer. In 1996, Jeffrey Harris (a former Director of NRO and Assistant Secretary of the U.S. Air Force) became the president of Space Imaging, but resigned and moved to Lockheed in May 2000, allegedly due (in part) to a clash with CEO Copple concerning the company's strategic directions.[22] Later, in January 2003, Copple also resigned and was replaced by Robert Dalal, as Space Imaging's most recent CEO. Dalal maintained that position until 2005 when Space Imaging merged with Orbimage.

Although management turnover (exemplified by the Space Imaging case) is not uncommon in many business organizations, in the fledgling industry of U.S. CRS, it seems important to establish continuity of people knowledgeable about the various aspects of operating a CRS firm. Such knowledge areas include how to manage a CRS company and its assets; how to market its products and services in a highly competitive domestic and international marketplace (which includes aerial imaging companies); how to interface and relate with USG entities that act as patron, customer, and regulator of the CRS industry;[23] and how to develop highly specialized markets for the geospatial products and services offered by the U.S. CRS industry. Thus, it is highly possible that management turnover can contribute to knowledge voids associated with the politics and economics of CRS technology. Of course, this phenomenon is not limited to the business world. Turnover of management or analytical expertise also affects knowledge assets in government, as well. Often key personnel are in their positions just long enough to learn their jobs and then move on to other positions – leaving knowledge gaps to be filled by new personnel.

Although the formative period of the U.S. CRS industry was characterized by occasional policy strife, periods of cooperation between Space Imaging and the USG were evident in the late-1990s. For example, on May 11, 1998, Space Imaging first partnered with the USG (NIMA) to distribute CRS imagery for mapping purposes (anticipating the successful launch of Ikonos system the following year). Moreover, on October 13, 1998, Space Imaging signed a three-year agreement with NASA to provide imagery from the soon-to-be-launched Ikonos satellite for NASA's research community as part of the SDB program. In December 2000, Space Imaging received a license from NOAA to operate a .5-meter CRS systems and a license in November 2002 from NOAA to operate a .4-meter system.

As the initial parts of this dissertation were being researched and written, Space Imaging was suffering from financial problems and was eventually acquired by Orbimage of Dulles, Virginia in a merger deal announced in January 2006; the combined company began operating under the brand name GeoEye. With the acquisition of Space Imaging, Orbimage (now GeoEye) and DigitalGlobe were the only two CRS firms left in the U.S. with operational CRS satellites in orbit. More details about Orbimage (GeoEye) are provided in the section following its competitor, DigitalGlobe.

DigitalGlobe

DigitalGlobe traces its linage to the WorldView Imaging Corporation (WorldView), which was formed in 1993 and received its CRS license in that same year. Later, in January 1995, WorldView became EarthWatch, Inc. through a merger with Ball Aerospace.[24] Several years latter, EarthWatch suffered its first technical setback when its Early Bird-1 malfunctioned in orbit after having been successfully launched by a Russian rocket four days earlier on December 24, 1997.[25] By 1996, WorldView was managed by Richard Herring (CEO and Vice President of Ball Aerospace).[26] In November 2000, EarthWatch attempted to launch QuickBird-1 on another Russian launch vehicle, but in that case, it failed even to reach orbit.[27] Later, in Sept 2001, EarthWatch changed its name to DigitalGlobe and launched its first successful CRS satellite QuickBird-2 on October 8, 2001. DigitalGlobe refers to QuickBird-2 without the numerical designation and simply calls it QuickBird.

Contrasting the corporate culture of the former Space Imaging and current DigitalGlobe is a fascinating and instructive endeavor and potentially sheds light onto how DigitalGlobe likely survived longer than Space Imaging in the highly competitive U.S. CRS marketplace and restrictive USG regulatory environment. Ultimately, Space Imaging's financial difficulties prompted it to merge with another CRS firm (Orbimage, described below) to solve its financial problems, whereas DigitalGlobe is still highly successful and boasts winning two $500 million contracts from the USG (NGA). Commenting on possible factors related to Space Imaging's unsuccessful bid for the $500 million NextView contract with NGA, Roger Fillion characterized the difference in corporate culture between the winner, DigitalGlobe, and loser, Space Imaging:

> Other factors were at play at the time – such as corporate culture. DigitalGlobe employees wore jeans and sneakers, much like at a startup. CEO Saterlee even wore shorts. Space Imaging was more formal. Executive wore ties and suits, more in line with the culture at Lockheed and Raytheon. Current CEO Bob Dalal has Lockheed roots. The previous CEO was a Raytheon veteran. ….. Attempts to loosen the atmosphere and build camaraderie didn't always sit well with the top brass [at Space Imaging or its parent companies].[28]

Of course, there were probably many other factors that contributed to the problems faced by Space Imaging before it eventually sold out to Orbimage in January 2006. Still, a relaxed corporate culture can potentially create better relations between management and technical workers by making the former more approachable and, thus, facilitating better communication of ideas that could lead to more effective product and service innovation and marketing.

Other CRS industry watchers have characterized problems with fledgling CRS firms traditionally being run by so-called "technical types" with little business acumen vs. "business-oriented CEOs."[29] During the formative stages of a CRS company, technical background is important in developing and launching highly complicated technical systems such as high-resolution earth observation satellites. Once the systems are in orbit and successfully operating, image products need to be sold to recoup the developmental investment costs and make a profit. At this stage, business and marketing strategies are key to the growth of niche-market CRS firms. Media reporting indicates that might have been the reason why in November 2005 a more business-savvy executive replaced Herb Saterlee, former CEO of DigitalGlobe, who has an MBA but came from the aerospace industry, which some have argued is too reliant on government contracts.[30] The new CEO, Jill Smith, has an impressive record of running IT-related companies and "has a high-tech background and boasts a master's degree from MIT's Sloan School of Management."[31] Reportedly, Smith wasted no time in reorganizing DigitalGlobe and revamping its operations and customer service.[32] Satterlee remained on at DigitalGlobe as chairman of the board, but left DigitalGlobe in February 2006 to become the CEO of Novariant, a Menlo Park, California firm specializing in GPS technology solutions for the agriculture, transportation, and mining sectors.[33] While DigitalGlobe might be considered to be more successful that Space Imaging in the long run, having won a couple of NIMA/NGA contracts, it had its share of financial problems under the watch of Satterlee.

A mix of technical and business savvy would be important to promote the interests of a high-tech satellite imaging company in the business of making a profit by marketing its imagery, both domestically and internationally. Obviously, a CEO with a business but not a technical background could always rely on key subordinates to provide technical advice and guidance and the reverse situation (i.e., technical but no business background) might also work in the same manner. Still, it is even more advantageous for the ultimate decisionmakers at CRS firms (i.e., CEOs) to be knowledgeable about their CRS systems, while effectively managing their multimillion dollar accounts and cutting costs in the highly competitive market of CRS, particularly when government contracts might not always be guaranteed for future corporate revenue.

Orbimage/GeoEye

Orbimage's history can be traced back to 1982, when Orbital Sciences Corporation (Orbimage's early parent company) was founded. Shortly after the passage of the Land Remote Sensing Policy Act in 1992, Orbital Sciences Corporation partnered with Litton Itek Optical Systems and GDE Systems to develop and launch the planned Eyeglass satellite. The venture incorporated in 1994 as Eyeglass International. Due to conflicts over marketing strategy, the joint venture broke up with Litton and GDE leaving the project and Eyeglass (which was latter renamed Orbimage) taking over. While Orbital Sciences Corporation was still the parent company of Orbimage, Gilbert Rye managed the firm as its president.[34] Orbital Sciences Corporation is no longer the parent company of Orbimage (currently renamed GeoEye). Reportedly, Orbimage went through Chapter 11 bankruptcy reorganization in 2003 due to financial problems, but was able to reach a deal to satisfy its creditors in 2003.[35] Previously, in November 2001, a launch failure of the Orbview-4 satellite contributed to the firm's financial and legal problems. Such technological risks, faced by the CRS industry, might not be significantly appreciated or understood by those in the USG who tightly regulate the CRS industry. Yet, ironically, it was the USG that saved Orbimage, with the award of the $500 million ClearView contract from NGA for CRS image acquisition.

Despite the difficulties it faced in the early 2000's, Orbimage was able to rebound and assist another ailing industry rival – Space Imaging – in a 2006 merger negotiated in 2005. According to a January 12, 2006 press release, Orbimage (Orbimage Holdings Inc.) completed its acquisition of the majority of all assets of Space Imaging and claimed to be the "world's largest commercial satellite imagery company.."[36] With the merger, GeoEye could now advertise that it operated two high-resolution CRS satellites (Ikonos-2 and Orbview-3) and would soon have a .41-meter resolution-capable EO satellite in orbit in late 2007 (GeoEye-1) to enable the company to provide the highest resolution imagery available in the CRS world.[37] The new company now operates from three U.S. cities – Thorton, Colorado (Ikonos operations center), St. Louis, Missouri (Orbimage satellite downlink and processing center); and Dulles, Virginia (GeoEye corporate headquarters). The merger garnered immense optimism among GeoEye's leadership and management personnel and provided a substantial boost in its prestige and future negotiating power for USG and international contracts and imagery sales.

Technica Inc.

During the Spring 2006 ACCRES meeting, a new CRS firm announced its intention to fill the gap of the "big three" left by Space Imaging's merger with Orbimage to form GeoEye. According to a statement issued at the meeting, Technica Inc. of Bethesda, Maryland received a CRS license from NOAA on December 8, 2005. The satellites planned to be built and launched by Technica will be called the "EaglEye" system. According to a Technica press release, four earth observation satellites will be built between 2006 and 2009, and the first satellite of the planned constellation (capable of producing half meter ground resolution imagery) will be launched in mid-2008 and the remaining satellites will be launched over the following eighteen months.[38] Technica, Inc. appears to be a consulting service for aerospace companies. Of note, the company representative mentioned at the Spring 2006 ACCRES meeting that it took them about six months to obtain their NOAA license (even though 120 days is supposed to be the norm mandated by Congress back in 1992).

Industry-Government Revolving Door

Industry-government relations are important to the success and growth of the CRS industry. Here, the politics of personal relationships can help win contracts and possibly influence CRS policy outcomes. Of course, one might ask the question: To bolster such relationships, is there a revolving door between government and the private service when it comes to key industry and government officials? Unfortunately, background information on executives of U.S. CRS companies is difficult to find, but available sources indicate that the former Space Imaging had CEOs and presidents that had significant government experience, whereas DigitalGlobe has had none. In the case of Space Imaging, Jeffrey Harris worked for the NRO and other IC organizations.[39] Although, information on government service was not identified for John Neer, John Copple, and Robert Dalal, all former executives of Space Imaging, each of them had experience in the aerospace industry which has defense contracts, and thus their contracts with the federal government would have been useful in their dealings with Congress and CRS policymakers and regulators.

On the other hand, it appears that DigitalGlobe's executives (Herb Satterlee with the company from 1998 to 2005 and Jill Smith from 2005 to the present) do not have government experience. Satterlee had a couple decades' experience at Boeing and Jill Smith, present CEO of the firm, has a background in the business world. Even though Space Imaging executives had more government or defense contractor experience than those at DigitalGlobe, the latter firm was more successful by receiving two multi-million dollar contracts from NGA and is still thriving, whereas Space Imaging had significant financial difficulties in the last several years and was eventually bought out by Orbimage (now GeoEye). It is counterintuitive to realize that the firm that employed senior executives with former government experience (Space Imaging) faired worse in the CRS business arena than the firm (DigitalGlobe) that employed senior executives with no such experience.

Orbimage has a mixture of revolving door (or pass-thru door) experiences with its chief executives. Past CEO of the firm, Gilbert Rye, retired from the military as a full c olonel and served in the National Security Council, which plays a significant role in drafting policies for U.S. CRS activities. He was replaced in 2001 by Matt O'Connell who remained in that position when Orbimage became GeoEye. Unlike Rye, O'Connell's background is in business (finance and mergers) and he is a lawyer.

Most likely there are revolving doors for lower-level executives of CRS firms to come from or enter (reenter) government service and vice-versa, however obtaining such data would be an extensive undertaking. Still, detailing the personal backgrounds and relationships (with the government) of current and former CEOs and presidents of CRS firms would be an informative study and could be made into a separate STS study. Of course, numerous industry officials below the top levels could have military, IC, or civil government experience, but seeking such information would even be more challenging that obtaining background information of the top executives. Nevertheless, it might be possible by using ethnographic methods (i.e., interviews). During my research for this dissertation, I identified a handy source for obtaining initial biographical and career data on these types of executives and it is zoominfo.com's key people directory.

Other Participants

The U.S. CRS industry involves more than just the current "big-two" CRS satellite firms. Although not fitting into the overall scope or focus of this dissertation, the CRS industry also includes aerial remote sensing and value-added (imagery enhancement and GIS) firms. Although the value-added and GIS segment of the industry complement and often support the CRS satellite companies, the U.S. aerial imagery sector often serves as a serious competitor to the CRS satellite industry. This fact needs to be considered by USG policymakers and regulators in crafting and implementing U.S. CRS laws, policies, and regulations, but my research has uncovered little information to support any claim that USG is fully cognizant of that dimension of competition faced by the U.S. CRS satellite industry. Aside from the aerial remote sensing industry, more emphasis seems to be placed on the foreign CRS arena and, even there, knowledge gaps generally appear to only be filled by sporadic studies requested by the USG (e.g., NOAA).[40]

U.S. Government

Remote sensing is still an arena dominated by governments, which have reasons other than economic incentives and constraints that drive their involvement in the market.

- George Tahu, John Baker, and Kevin O'Connell (1998)[41]

The USG plays a key role in promoting and regulating the U.S. CRS industry. Insights into the political and bureaucratic relationships of the USG with the CRS industry are instructive in comprehending the complex issues surrounding CRS policies and regulations and how the high technology of space imaging systems affects public-private relationships and in turn how such relationships affect the utilization of that technology. The following subsections examine the role of various components of the USG in crafting and implementing CRS laws, policies, and regulations to simultaneously promote the U.S. CRS industry and protect the national security, foreign policy, and international obligation of the U.S. As implicit in the above citation of Tahu, Baker, and O'Connell, national security and foreign policy issues are often viewed as powerful impediments to promoting a robust CRS industry in the U.S. Yet, the knowledge gap that needs to be filled is incomplete or inadequate comprehension of how such issues can be resolved by the various ways that high-resolution CRS imagery can be used to bridge the gap between national security and foreign policy concerns on the one hand and promoting the CRS industry on the other hand. Put differently, the USG (particularly its national security and foreign policy establishments such as DOD and DOS, respectively) need to be encouraged to view CRS imagery as a tool for resolving international conflicts, territorial disputes, peace negotiations, and humanitarian strife, etc., thus contributing to U.S. national security and foreign policy objectives.

There are many examples of how CRS imagery can be used for such diplomatic and bureaucratic purposes. One such example is how CRS was effectively used to reach the 1994 Dayton Agreement. Specifically, peace negotiators in Dayton, Ohio used SPOT imagery to produce digital maps of the conflict area in the former Yugoslavia.[42] CRS imagery (i.e., Canadian Randarsat-1 imagery) was also used to help resolve border conflicts in 1998 between Ecuador and Peru (by creating up-to-date maps of the border region between the two countries).[43] While the U.S. CRS industry does not currently offer radar imagery, it does have panchromatic imagery, which can be used for the same purpose (i.e., digital mapping) given favorable atmospheric conditions. Additionally, CRS can be used to support disaster and humanitarian relief operations (particularly in those areas for which DOS may be interested or involved). All of these CRS application-based solutions can potentially create a more peaceful and amicable world and such a condition is presumed to be good for national security and international relations. Unfortunately, certain sectors of the USG tend to focus on the detrimental effects of CRS imagery in the hands of adversaries, instead of the multitude of beneficial uses of high-resolution earth observation data. The trick is to adeptly link political and humanitarian solutions to the broader concept of national security and mutually beneficial diplomatic relations.

High-resolution CRS imaging technology has only been around for a short period of time (i.e., less than a decade considering the 1-meter Ikonos system that was launched in 1999) and, thus, it is understandable that USG officials have not become extremely familiar or comfortable with a dual-use technology that could be used to bridge the gap between industry and government goals and perspectives. To bridge this gap, industry has had to develop allies within the USG. Among USG organizations, Congress has been one of the staunchest allies of the U.S. CRS industry and has played an especially pivotal role in promoting an environment for successful CRS business operations by passing legislation favorable to the CRS industry. Such laws have then been followed by executive branch policies and regulations that both promote and govern U.S. CRS operations. In the short political history of modern-day U.S. CRS, laws (the domain of Congress) have usually but not necessarily preceded CRS policies and regulations, and thus, it is the Congress to which I first turn in this section.

Congress

Analyzing how the legislative branch of the USG works and thinks is valuable in understanding how it crafts legislation that governs or are spawned by remote sensing policies crafted and issued by the administrative branch. It also demonstrates how difficult it is for those in the U.S. Congress to comprehend (i.e., span the knowledge gap concerning) the highly esoteric and complex world of remote sensing for which they initiate, debate, and pass (or defeat) legislative actions affecting that technology. Such knowledge gaps will be discussed in greater detail below. At this juncture, if we consider U.S. CRS capabilities and activities to be analogous to building a house, Congress accomplishes its role as political constructor of CRS by creating its foundation and ensuring that its walls, ceilings, and internal fixtures are adequately constructed by other CRS actors in the USG (i.e., an oversight role). Understanding how this socio-political construction process takes place requires insights into the goals, attitudes, beliefs, and knowledge of Congress in performing its roles as one of the CRS policy stakeholders.

Congress constructs CRS by passing laws (i.e., establishing the legal foundations for U.S. CRS), exhorting the administration into implementing such laws (through executive branch policies, regulations, and procedures), funding particular CRS-related programs (such as budget allocations for NGA's CRS imagery purchasing programs and NASA's SDB program), representing industry (particularly if their firms are in their states or Congressional districts), and by soliciting knowledge from executive branch officials and other CRS experts while sharing its knowledge of various CRS issues. These are complex parameters of the socio-political construction process. Although the perspectives, goals, attitudes, and knowledge areas on CRS vary according to each individual member of Congress, a thread of commonality can be sketched based on my research of the public records of hearings and legislative actions conducted by Congress since 1984.

The goals of Congress in constructing a U.S. CRS capability involve promotion of and support to the CRS sector of the space industrial base. These goals were accomplished through passage of the Policy Act of 1992 and the Commercial Space Act of 1998. Seemingly contrary goals entail promoting the CRS industry while simultaneously restricting its activities, when necessary. An example of this regulatory goal is the Kyl-Bingaman Amendment to the FY 1997 National Defense Authorization Act. That amendment was the result of 64 senators and several

House members writing to DOC Secretary Ron Brown about their concerns over Eyeglass International's (forerunner of Orbimage, now GeoEye) attempts to reach an imagery distribution and ground station operation agreement with Saudi Arabia.[44] Another less salient but likely goal in the CRS policy process is promotion of jobs in one's own state or Congressional district. Finally, while building the CRS house, Congress aims at balancing national security concerns with industry growth. In doing so, Congress plays the role of mediator. Congressman Dan Glickman made this goal quite clear in 1994 when he stated: "In this area the Committee seeks middle ground between the obligations of government to safeguard national security and the needs of industry to compete in the worldwide marketplace."[45]

Members of Congress have demonstrated various attitudes towards U.S. CRS. Positive attitudes include desires to preserve U.S. leadership in space activities and demonstrate national pride in doing so. Conversely, negative attitudes consist of dismay at foreign competition in land remote sensing capabilities, cynicism about imagery costs borne by government agencies and scientific researchers, and outrage at the administration's slowness in processing CRS licensing requests. Other factors in the socio-political construction process are beliefs and perspectives, which as I will argue in Chapter 4, often stem from knowledge reservoirs (some of which are inaccurate) instead of just experiences or hunches. Numerous members of Congress have expressed their beliefs that CRS has tremendous value. They have also manifested unrealistic beliefs that CRS can be highly profitable without substantial government subsidies (or gradually decreasing subsidies). Such unrealistic beliefs resulted in the 1984 Commercialization Act, which led to a policy failure of significant magnitude (as discussed in Chapter 1). Finally, several members of Congress express their beliefs that CRS can potentially be used by adversaries of the U.S. to do harm to U.S. national security and foreign policy interests. These beliefs are very realistic and help create allies in the administration, particularly at DOD, DOS, and the IC.

The fourth factor in the social construction process of CRS is knowledge of and expertise (or lack thereof) in CRS and related issues. During the early 1990s, Congress appeared to be more versed with Landsat issues than with CRS. This is because they dealt with Landsat issues for many more years than with CRS issues. Moreover, research of the relevant literature revealed that Congress has often been confused with or fairly unknowledgeable about CRS marketing and imagery pricing factors. This knowledge void resulted in non-business-friendly provisions of the 1984 Commercialization Act, which did not allow for discriminatory pricing of Landsat imagery by the commercial operator EOSAT. Such was one of the factors that caused the Landsat commercialization venture to slowly collapse. Fortunately, the 1992 Policy Act corrected that situation by allowing CRS firms to set various pricing standards (but only as a result of being educated by CRS industry representatives). Other areas of adequate knowledge demonstrated by members of House and Senate committees dealing with CRS issues were their familiarity with the utility of CRS imagery to the military during the 1991 Gulf War and also concerning the myriad civil applications of CRS. An example of the latter knowledge area could be equated to Congressman Nick Smith's introduction of proposed legislation (H.R. 2634) related to the use of remote sensing for agricultural purposes.[46]

Notwithstanding these types of knowledge competencies, members of Congress have had difficulty with some of the more esoteric, technical aspects of CRS. A case in point occurred just a couple of years after a joint Congressional hearings in 1994 on CRS policy and licensing issues, when several committee members and witnesses voiced how difficult and complex CRS was in reaching a unified policy on that technology. Later in 1996, Congress began debating the proposed Commercial Space Act of 1997 (H.R. 1702), which eventually was enacted in 1998, and similar observations were voiced. For example, during the May 21, 1997 hearing on a bill entitled "The Commercial Space Act of 1997, " Subcommittee Chairman Dana Rohrabacher began discussing the legacy of commercial remote sensing and specifically referred to the first civil remote sensing satellite as the "Earth Resources Terrestrial Survey" satellite.[47] It is unclear where Rohrabacher got the term "terrestrial survey" for the initials TS in the acronym ERTS. Even though that is what the satellite does, the actually satellite system (which was later renamed Landsat-1) was originally called the Earth Resources *Technology Satellite* (italics mine).[48] Even as late as January 2004, ERTS was incorrectly called "Earth Resources *Test* Satellite in a study for ASPRS."[49] These small knowledge voids are understandable and it might be argued that even legislators have so much to do that it is hard to keep up with specific details in the arena of remote sensing. Nevertheless, it would be more helpful to the CRS industry if lawmakers had a higher expertise in CRS issues or at least rely on such from internal or external sources. At one time, Congress had an internal organization to educate itself on these matters and that was the OTA. Unfortunately, Congress did away with OTA in 1995.[50] Although the causes of these knowledge voids are difficult to determine, the end result is that members of Congress risk confusing U.S. civil or CRS satellite systems or mixing up key articles of legislation.

Even the proper terming of remote sensing-related policies and legislation appears to confuse legislators and exemplifies knowledge voids concerning CRS issues. For example, Rohrabacher referred to the Land Remote Sensing Act of 1992, whereas it is entitled the Land Remote Sensing *Policy* Act of 1992 [italics mine])[51] and the same slip was made by a fellow committee member, Robert Cramer, Ranking Minority Member of the Subcommittee.[52] Even a representative of the CRS industry and former expert in remote sensing (i.e., former Director of the NRO), Jeffrey K. Harris, then President of Space Imaging EOSAT, correctly referred to the Land Remote Sensing Policy Act of 1992,[53] but then later, referred to the same act by leaving out the term "Policy."[54] In this case, a politician got it wrong, whereas an industry expert partially got it right. It might seem like a minor slip in accurately stating the designation of key law governing U.S. CRS activities, but not using the term "Policy" makes it difficult to differentiate between the Land Remote Sensing Commercialization Act (aka Landsat Act) of 1984 and the Land Remote Sensing Policy Act of 1992. Actually, the term "Policy" is very important when mentioning the specific Act, as it distinguishes it from the 1984 Act. Other instances of confusing these two major Acts are discussed in other parts of this dissertation.

Despite the minor knowledge gaps, the "Commercialization of Space" hearings were very informative and served to educate subcommittee members about the value of CRS. The Subcommittee Chairman even said that he would be asking questions such as what an "algorithm" and "other unknown terms" were?[55] Chairman Rohrabacher also inquired about what the industry needed from Congress to succeed in the CRS business. Harris responded by stating that industry sought a "stable policy" and "industry-government cooperation" creating a technical foundation that facilitates understanding of the commercial market, etc."[56] Other excellent questions from the Subcommittee were on potential foreign competition and, overall, the hearings seemed congenial and showed cooperation between the legislators and industry, academia, and think tank representatives.

The hearings continued on June 4, 1997 for the CRS part of the proposed Act (Part III). That particular session reflected concerns over the national security implications of CRS, apparently stemming from concerns voiced by a lawyer at DOS.[57] Key witnesses providing testimony at the hearing were James Baker (then Undersecretary of Commerce for Oceans and the Atmosphere, and head of NOAA), Cheryl Roby, Principal Deputy to the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence (C^3I), and Mike Swiek, Executive Director of the U.S. Global Positioning System Industry Council. Issues discussed by the DOD representative, Roby, were national security concerns and shutter control issues. However, Roby's testimony (reflecting her Department's concerns) did not account for current and especially future capabilities that would render shutter control constraints on the U.S. CRS industry moot or ineffective. Moreover, Roby's testimony manifested another possible knowledge void during the hearing. Responding to a question by the Subcommittee Chairman about the U.S.'s ability to fly remote sensing satellites over any country or territory claiming sovereignty based on Open Skies concepts (and also a U.N. resolution that he didn't mention), Roby stated, "Yes. It is our policy that remote sensing capabilities are available to fly anywhere over any spaces that's not sovereign country, the actual use of remote sensing."[58] Perhaps it was a slip of the tongue, but Roby's statement seems to ignore the fact that the 1967 Outer Space Treaty[58] permits overhead observation of sovereign territory of any state by space-based imaging systems. Roby's statement could be erroneously construed to mean that such was not permissible according to international legal regimes, whereas, in fact it is permissible. According to Ram Jakhu, Professor of International Law at McGill University (Canada), no state protested the overflight of its territory by artificial satellites following the launch of U.S. and Soviet remote sensing satellites in the post-Sputnik era. According to Jakhu, "Such a failure to protest was considered to be a 'tacit or implied consent or agreement' among States to allow the free passage of satellites [and ostensibly imaging functions of such satellites] over their territories."[60]

Additionally, Roby's answers to questions on specific shutter control conditions were somewhat vague or not adequately phrased, and instead equated potential shutter control mechanisms based on U.S. regulations with a request to the French not to release its SPOT imagery (ostensibly to anyone other than Coalition partners) during the 1991 Gulf War. Asking someone, especially a foreign state, not subject to U.S. regulations, to not provide imagery potentially impacting U.S. military operations and getting voluntary cooperation is not the same thing as imposing shutter control restraints on U.S. CRS systems, whereby voluntary compliance is not an option.

The opening statement of another Subcommittee member, Sheila Jackson Lee, manifested a starker example of a knowledge gap. Directed to Roby, Congresswoman Jackson Lee asked: "I understand, in reading your testimony, that you stated that DOD realizes that it would be inappropriate to call for shutter control of U.S. commercial systems unless we have agreements with foreign governments for some measure of controls on foreign imaging."[61] The ability or appropriateness of the USG imposing shutter control has nothing to do with agreements with foreign governments. Jackson Lee might have confused this issue with the voluntary agreement of the French during the Gulf War. The actual policy mandates the closing of satellite shutters when imagery derived from open shutters over sensitive targets or areas is of a quality that "exceeds" foreign systems – a big difference. Thus, it seems logical and prudent that knowledge gaps be narrowed, especially during legislative actions. Obviously, that is the purpose of Congressional hearings (forums for the interaction of politicians and non-politicians).

While Congress has conducted these types of hearings to inform and educate itself about CRS activities, it has also taken the opportunity afforded by such hearings to chastise the executive branch concerning inefficient CRS policies and regulatory regimes. During the early part of the transitional period (1992-1994), Congressional committees dealing with CRS issues tended to back industry (i.e., shared similar views and goals for the construction of CRS), whereas the administration was either opposed to giving industry a free pass to develop and operate high-resolution CRS systems or was experiencing growing pains in adapting to the new era of information transparency and globalization that CRS would, in part, bring about. Congress had produced the Land Remote Sensing Policy Act in 1992 to help stimulate the creation and growth of a U.S. CRS industry, but it has occasionally had strained relationships with the executive branch in getting that Act implemented via White House policy statements and DOC regulations. To encourage the executive branch to expedite CRS regulations and licensing procedures, Congress held a hearing in 1994 and enlisted the support of the CRS industry by soliciting testimony from key industry representatives to get to the bottom of the CRS licensing morass at the time (i.e., 1992-1994). Even though the Policy Act was passed in 1992, administration officials had still not come up with an implementation policy by early 1994 and were dragging their feet in expediting CRS licensing applications as called for by the Policy Act. As a component of social construction of CRS, this inter-branch conflict reveals underlying issues of concern over the national security implications of CRS and, perhaps, the once-held monopoly of high-resolution imagery data by the executive branch. CRS imagery is a valuable political and policy tool because it can provide information with which Congress or other public-interest groups can debate and challenge administration actions and policies and expanded availability of such CRS data can potentially threaten the administration's monopoly on policy-relevant information.

Even prior to this landmark Congressional hearing, one scholar who studied the political dynamics of CRS policymaking believed that industry could be in a position to bolster the power of Congress vis-à-vis the executive branch by providing CRS imagery to the public or to Congress (other than through House or Senate intelligence committees), which could be used to assess and debate foreign policy issues. For example, Richard Davis wrote in August 1992, just two months prior to the passage of the Policy Act, about a possible tipping of power between the two branches based on information generated by CRS satellites. Essentially, Davis viewed the CRS operators as "new players into [in] the policy arena,"[62] thus, expanding the field of players in U.S. technology policymaking. Yet, the industry has had to play a difficult balancing act of trying to please both the Congress as lawmakers and the executive branch as rulemakers to obtain favorable legislation, policies, and regulations for industry's planned CRS satellite operations.

So how do the aforementioned factors (i.e., goals, attitudes, beliefs, and knowledge areas) relate to each other or lead to certain views regarding U.S. CRS policy issues? The more one knows about the potential harm that CRS imagery can do to a nation if used for aggressive or offensive military or economic (i.e., exploitative) purposes, the more one might naturally lean toward a closed-information paradigm. Conversely, the less one knows about the potentialities for misuse of CRS imagery and more about its beneficial uses in scientific and economic sectors, the more one might tend to gravitate towards the openness or transparency viewpoint.

In the CRS arena, if one has a viewpoint that CRS activities should be as unfettered as possible, one would endeavor to establish goals and objectives that attain that state. Further, it could be argued that attitudes and beliefs are a result of knowledge; yet, they are hard to change even in the face of knowledge claims that refute original knowledge of a particular subject or issue. In the area of CRS, members of Congress manifested a fairly common set of beliefs and attitudes favorable to the U.S. CRS industry, and as a result, were able to focus their attention on establishing the legal foundations for licensing and operation of CRS satellite systems by U.S. companies in the final decade of the 20th century.

Executive Branch

As social and political actors, the executive branch constructs CRS technology by issuing policy directives that promote the CRS industry and prescribe what policy and regulatory requirements that industry must meet. Specific interests, assumptions, and goals are detailed under discrete headings for executive branch agencies, departments, and offices. Overall, the interests of the executive branch in CRS matters are to promote and enhance the economic viability of the U.S. CRS industry (as a sector of the U.S. space industry) to sustain a defense industrial base, create economic growth (through job expansion and product sales), increase government revenues from taxation of the CRS sector, sustain the U.S.'s leadership in space systems and activities, and provide alternate sources of imagery data for DOD, the IC, and other federal government agencies. Its interests also lie in its motivations to protect U.S. national security and foreign policy interests while simultaneously promoting the CRS industry. Its assumptions are also based on the perception that growth and economic profitability of the CRS industry will support national security in its economic dimensions.

The executive branch implements such goals by issuing policy statements and documents and providing Congress with the information it needs to produce CRS legislation. Key policy documents during the transitional period of U.S. CRS (i.e., 1992 to the present) have been PDD-23 (1994), the National Space Policy (1996), the Commercial Space Act (1998), and the Commercial Remote Sensing Space Policy (2003). Each of these policy directives have communicated the executive branch's interests, goals, and assumptions in broad sweeping language and have called for more detailed implementation procedures to be crafted and used by responsible agencies and offices within the executive branch (primarily DOD, DOS, IC, DOC, NASA, and DOI). Appendixes C and E of this dissertation contain the full text of the fact sheets on PDD-23 and the CRSSP, respectively.

White House. Compared to other components of the executive branch, such as the Departments of Commerce, Defense, Interior, and State and agencies such as NASA, etc., there seems to be sparse public-source information on the White House's relationship with the U.S. CRS industry. The National Science and Technology Council (NSTC), Office of Science and Technology Policy (OSTP), and the National Security Council (NSC) exercise varying degrees of influence over the U.S. CRS industry through their inputs to CRS policymaking process, decisions on licensing and operational controls, and interpretation and implementation of CRS export policies and controls. Currently, the most salient influence of the Assistants to the President for National Security Affairs and Science and Technology over U.S. CRS satellite operations is their role in helping the USG reach consensus on various CRS-related national security issues such as licensing and, most importantly, shutter control decisions. Should there be disagreements over these issues among the Secretaries of Commerce, Defense, and State, the aforementioned Assistants to the President attempt to resolve such conflicts and, if unsuccessful in that endeavor, refer the matter to the President for an ultimate decision.

NSTC, OSTP and NSC also have influence over U.S. CRS licensing and operational matters through their membership in the Remote Sensing Interagency Working Group (RSIWG). As a senior group of CRS specialists, the RSIWG reports to the NSC. Generally, broad policies on U.S. CRS are formulated by the NSTC and NSC, with inputs from other relevant parts of the USG. The first major policy that affected and inspired the U.S. CRS industry was PDD-23, which has been discussed at length in this dissertation. PDD-23 was replaced by the 2003 U.S. Commercial Remote Sensing Space Policy (CRSSP) issued by the George W. Bush administration.

An example of broad policy visions and goals emanating from the White House was the 1996 National Space Policy, which among other policies, established the goal of “enhancing knowledge of the Earth” and supporting and enhancing “U.S. economic competitiveness in space activities…,”[63] which at that time were focused mostly on the Landsat system since U.S. commercial land observation satellites were not yet in operation. The policy also mandated that USG agencies were to make all efforts to purchase and use CRS imagery to fulfill their missions.[64]

The U.S. CRS industry received a significant boost with the issuance of the 2003 CRSSP by the White House, which called for the USG to “sustain and enhance the U.S. remote sensing industry.”[65] Yet, to fathom how complicated the policy could become in its implementation process, one only needs to examine the various proposals on how to effectively execute that policy. For example, as recently as May 2005, the USGS proposed establishing a Senior Management Oversight Committee (SMOC) involving NOAA, USGS, NGA, NASA, and the Department of Agriculture to boost collaborative efforts at distributing burdensharing for CRSSP execution.[66] Further, participating federal agencies in CRSSP implementation programs involved a vast array of government actors such as DOD, DOC, DOI, Department of Agriculture, Department of Homeland Security (DHS), Federal Geographic Data Committee, Environmental Protection, Agency, Department of Transportation, NASA, and the National Capital Planning Commission.[67] If the U.S. CRS industry needed to bypass the SMOC and informally interface directly with each element of the vast USG bureaucracy to promote its CRS business interests, it would be faced with a huge and complicated task, requiring deep knowledge and understanding of the interworkings of each USG entity that could serve as industry’s supporter or customer.

Department of Commerce. Policy confusion on how to handle CRS issues seems to have continued into the early 2000s. A good example is Congressional perspectives on DOC and its mandated role in promoting the U.S. CRS industry and making it competitive in the global remote sensing marketplace. The most notable advocate for CRS in the federal bureaucracy is the Office of Space Commercialization (OSC; recently renamed the Office of Space Commercialization and National Space-Based Positioning, Navigation, and Timing) within NOAA's Satellite and Information Services, DOC. It appears that the USG (specifically Congress) was considering moving CRS licensing authority from NOAA's National Environmental Satellite, Data, and Information Service (NESDIS) to OSC. Although OSC is also an office within NOAA (both NESDIS and OSC fall under NOAA's Satellite and Information Service), and thus licensing authority would still remain within NOAA, OSC would face a learning curve in CRS licensing issues and procedures if this interoffice transfer were to take place.

On November 5, 2003, after issuance of the 2003 CRSSP Policy, Congress held hearings on a bill (H.R. 3245) entitled the "Commercial Space Act of 2003." In the summary section of that bill, it was recommended that the licensing authority for CRS satellite firms (currently held by NESDIS) be given to the Office of Space Commerce [sic; actually, the Office of Space Commercialization), to wit: "The bill specifies that the licensing authority for private-sector remote sensing systems within the Commerce Department be delegated to the Office of Space Commerce."[68] Again, we encounter an example of knowledge voids for members of Congress; this time concerning the official titles of government organizations as referred to in legislative actions. The original Office of Space Commerce, established in 1988 by DOC, was renamed the Office of Air and Space Commercialization a decade year later in 1998. Ironically, it was Congress itself that renamed the entity as the Office of Space Commercialization in 1998, several years prior to the debate and enactment of the Commercial Space Act of 2003.[69] OSC was recently transferred from DOC's Technology Administration to NOAA in 2005. Although these knowledge glitches are seemingly minor, they seem to indicate a pattern of misunderstanding of CRS-related entities and their official supporters among key USG officials and lawmakers.

OSC participates in the CRS policymaking process, such as being a key member of the Space Policy Coordinating Committee (Space PCC) under the NSC and OSTP. OSC also acts as an advocate for and represents the industry in helping to promote the latter's interests and economic viability. OSC also works with other industry-friendly organizations such as the International Trade Administration (ITA) and the Bureau of Industry and Security. It almost goes without saying that OSC has a productive relationship with the CRS industry. Regarding its support to industry, the OSC's mission statement is:

> …..to promote the growth of U.S. commercial remote sensing activity by contributing to the development of U.S. Government policies affecting the industry, voicing the industry's interests in U.S. Government interagency discussions, and representing U.S. commercial interests in international negotiations.[70]

Finally, to provide a salient example of the tight relationship between NOAA's OSC and the CRS industry or its current or former backers, one only needs mention the fact that on February 1, 2006, NOAA issued a press release announcing the appointment of Edward Morris as the newest Director of OSC.[71] Ed Morris previously worked for Orbital Sciences Corporation of Dulles, VA, the former parent company of Orbimage (now GeoEye).[72]

National Oceanic and Atmospheric Administration [NOAA]. With the passage of the 1992 Policy Act, DOC delegated its CRS licensing authority to NOAA but still retains authority for resolving licensing issues (brought up by other relevant departments) and coordinates licensing actions with other Departments and agencies such as DOD, DOS, and the IC, respectively.[73] NOAA hosts a policy/regulation advisory body, which goes by the title Advisory Committee on Commercial Remote Sensing (ACCRES) and was established in 2002. ACCRES advises NOAA on its licensing regulations and administration and consist of twelve to fifteen committee members. NOAA also chairs an informal Interagency Remote Sensing Working Group (NIIRS WG), which includes staff members from DOD, IC, DOS, and USGS.

On September 13, 2005, ACCRES held its fall meeting and I attended its public session. Just prior to the start of the session, I spoke briefly with Joanne Gabrynowicz about knowledge gaps and how they might affect policymaking/rulemaking in CRS. She replied that such knowledge voids are often due to high turnover rates in government bureaucracies and that such phenomena as it relates to government agencies involved in remote sensing policy was covered in Pamela Mack's study of the early Landsat program.[74] An example of this turnover problem (as contributing to knowledge voids) is exemplified by a previous NOAA staff member; during a September 2005 NOAA workshop on CRS licensing. During the workshop, it was revealed that Timothy Stryker, predecessor to the current chief of NOAA's Satellite Activities Division, was not an expert on synthetic aperture radar (SAR) applications of CRS and only had ten months experience before leaving that position.[75] CRS is a highly complex activity and ensuring compliance of and monitoring its activities is a daunting task requiring human resources and in-depth knowledge of the subject matter of CRS. One question asked during the workshop (by an unidentified participant) was whether NOAA had an adequate staff to perform all of its duties and functions. The response was that they do the best that they can.[76]

During the aforementioned public session of the Fall 2005 ACCRES meeting, Committee Chair Kevin O'Connell briefed on his recent experiences with European efforts to federate (joint development and funding) of space remote sensing activities and developments in the mini-satellite R&D arena in Europe. Knowledge of these activities, which NOAA tracks, is extremely important and significantly informs U.S. CRS policies. Kay Weston, Chief of NOAA's Satellite Activities Branch, briefed the committee and public participants on a study that NOAA would conduct in October 2005 on the international remote sensing market (which will project developments in that market out to 2015).[77] That study was to be used by NOAA in making policy/regulatory decisions.

NOAA has been aggressive in its efforts to fill knowledge gaps in understanding CRS issues and has relied on external sources of information on and analyses of the subject. To fill a knowledge void about how NOAA's interim regulations would affect the economic viability of the CRS industry, DOC requested in 2001 that RAND conduct a study on the risks faced by the CRS industry in the 21st Century. RAND determined that the CRS industry faced four risks (technical, market, international competition, and policy/regulatory risks).[78] Of the four risks, NOAA would mainly have been concerned with the policy, or more so, the regulatory risks, since NOAA's relationship with the CRS industry was that of regulator. According to RAND, "…U.S. government policies and regulations exert a major influence on the ability of U.S.

remote sensing satellite firms to realize their competitive potential in both the domestic and international marketplace."[79]

Those in the know would likely define technical risks as hardware and programmatic (financial) risks, whereas actors less familiar with the technology and programmatic aspects of developing and operating CRS systems would probably just think about the hardware risks. USG policymaking organs and actors would likely fall into the category of those that are less familiar with the technical aspects of CRS vis-à-vis industry itself or those that study it, such as RAND. Similarly but to a lesser extent, perceptions of market risks would naturally vary according to actors or organizations. Obviously, the CRS industry would be most knowledgeable about its market or economic risks. Industry is directly involved in making profits from their CRS ventures, whereas government officials might have difficulty in appreciating the market risks faced by industry. That is one of the reasons why NOAA commissioned the 2001 RAND study. Thus, government definitions of market risks for CRS could be much narrower than definitions offered by industry because the risks involve a significant array of factors (i.e., foreign competition, competition from aerial imaging firms, imagery pricing mechanisms, imagery user bases and demands, and overall structure of the geospatial marketplace, etc.) more familiar to CRS satellite operators.

The definitions of policy risks would likely be the most varied among relevant actors. Industry would likely say that policy/regulatory risks are higher than what USG policymakers and regulators would consider or determine. For example, shutter control (until recently, the most contentious of all policy/regulatory risks) was of major concern by industry because it felt that regulators and other related agencies (i.e., DOD and DOS) might arbitrarily impose such restrictions for less than serious national security or foreign policy crises. Conversely, USG officials would argue that such policy risks would be low or minimal and that shutter control restrictions would only be imposed for limited areas and cases and for the shortest time(s) possible.

As RAND pointed out in its 2001 study for NOAA, the U.S. CRS industry viewed policy risks as consisting of four types: performance restrictions (i.e., resolution limitations), operational constraints (i.e., shutter control), policymaking uncertainties (i.e., unclear and nonspecific regulatory provisions), and lack of an internal USG advocate for the CRS industry.[80] USG officials would generally see such risks as either minimal or necessary to preserve U.S. national security and foreign policy objectives and that a resilient space industry should work around such requirements.

Here we have opposing views (perception gaps) on the significance of the aforementioned risks. The social construction aspect of this example is that the dominant views will influence how CRS laws, policies, and regulations will be crafted and implemented (which then determines what type of CRS system are to be built). Dominance of viewpoints is addressed in STS theories such as Thomas Kuhn's concept of scientific paradigms and Weibe Bijker's discussion of dominate social groups in SCOT theories.[81] If government views are dominate in the policymaking process, they will (and have) result(ed) in regulatory provisions such as shutter control, broad definitions of national security and foreign policy concerns over CRS, and performance constraints such as 5-meter restrictions on CRS radar systems. If industry's views were dominant (they haven't been but are inching in that direction), they would help shape more industry-friendly CRS policy and regulatory regimes.

Knowledge gaps could constrain government actors in comprehending how policy risks potentially translate into economic/market risks for the CRS industry (i.e., how they affect their foreign business relationships and competition of U.S. CRS systems with foreign systems offering CRS imagery on the world market, etc.). Their decisions, hampered by knowledge gaps or bolstered by knowledge reservoirs, significantly affect what type of remote sensing technology is developed and deployed and how it is used (a prime subject area for the SCOT program). RAND did an excellent job of defining the policy risks as viewed or defined by industry and characterizing such risks themselves. RAND's assessment was that, "In particular, the government's policymaking process has yet to achieve [i.e., as of 2001] the degree of predictability, timeliness, and transparency that commercial remote sensing firms need if they are expected to operate effectively in the highly competitive and rapidly changing global marketplace."[82]

It is important to understand that the regulatory environment created by NOAA, but with input from other USG agencies, extremely complicates NOAA's and the USG's relationship with the U.S. CRS industry, as RAND researchers saw it. The USG plays multiple roles as "regulator (i.e., NOAA], customer [e.g., NIMA, now NGA], patron [i.e., NASA's old SDB program], and potential competitor [Landsat-7 and declassification of NTM imagery]."[83] Moreover, a potential conflict of interest between the role of regulator and potential competitor can be seen in the decision to designate NOAA as the operator of the future Landsat-7, based on the provisions of PDD-3 [NSTC-3] and an interagency plan (between NASA, NOAA, and USGS) in 1994.[84] Since then, NOAA lost its mandate to operate Landsat-7 in October 1998 and after NASA took over that role. USGS finally assumed the operational role from NASA and became the sole operator Landsat-7 in 2001.

<u>State Department</u>. DOS seems to have dual interests in CRS; One, that of conferring with DOC on CRS licensing issues and providing advice to DOC should shutter control issues arise; and two, that of wanting to promote the use of CRS to maintain the international obligations and foreign policies of the U.S. (since CRS imagery has and continues to be useful in various foreign policy agendas and international relations of the U.S.). However, the latter goal does not seem to be as well communicated to the public as the former goal. For example according to (a now somewhat dated) DOS website on its Bureau of Nonproliferation, part of the Bureau's mission is [was] to "promote the U.S. interests in the control of satellite remote sensing technology."[85] The term "control" in this mission statement ostensibly refers to DOS's authority to administer the U.S. Munitions Control List (USML). As such, DOS is in the primary position of controlling exports of satellite systems and technology, but not the data produced thereby. This distinction is occasionally misunderstood by Congressional committee members dealing with CRS issues.

Until recently, the DOS office responsible for remote sensing satellite technology (considered as a dual-use technology) control was the Office of Export Control and Conventional Arms Nonproliferation Policy (ECNP), under the Bureau of Nonproliferation (NP). However, recent information shows a reorganization of the Nonproliferation Bureau (now called the Bureau of International Security and Nonproliferation (ISN)) and the old ECNP Office. The ISN was formed out a merger of the old NP Bureau and the Bureau of Arms Control. Previously handled by ECNP, CRS satellite technology transfer issues now come under the purview of the ISN's Office of Conventional Arms Threat Reductions (CATR). According to its mission statement, ISN/CATR assumed the lead role in "all matters related to "….U.S. security policies related to commercial remote sensing."[86] Here, we have an instructive example of the social construction of CRS into arms or munitions, rather than as just instruments or commodities for peaceful scientific or economic purposes. This comes from the perspective that CRS is a dual-use technology, capable of being used for military or non-military purposes. Such perspectives have changed over the years with CRS imaging systems being placed on DOS's US Munitions List (USML), then switched back to DOC's Commerce Control List, then again placed back on the USML, depending on which US administration was in power at a particular time.

Even DOS officials are not immune to knowledge voids and unfamiliarity with the complexities of CRS policies and regulations. For example, in remarks delivered at the Symposium on "Viewing the Earth: The Role of Satellite Earth Observations and Global Monitoring in International Affairs" held on June 6, 2000 at The George Washington University, David B. Sandalow, Assistant Secretary of State (Bureau of Oceans, Environment and Science), discussed the so-called "shutter control" provision of the 1994 PDD. According to Sandalow:

> The President's [1994] policy also specifies that the government can limit collection or distribution of data by U.S. commercial satellites during specific periods when national security or foreign policy interests could be compromised (also known as "shutter control."). For example the "shutter control" provision could have helped prevent Iraq from gaining access to commercial satellite imagery during the Persian Gulf War in 1991.[87]

There are several inaccuracies and misconceptions associated with this statement. First, the only two Western commercial satellites in orbit during the 1991 Gulf War were the French SPOT satellite (10-meter resolution) and the Landsat (30-meter resolution). Although the French were convinced not to share their CRS imagery with Iraq (largely due to their forces participating in the Allied Coalition efforts), the 1994 PDD (even if it had been issued earlier in 1991) would have had no jurisdiction over the French. Of course, the Landsat system was a U.S. system and thus subject to U.S. laws and policies, but it's hard to think of the Landsat as a truly commercial satellite, even though the U.S. government was attempting to commercialize its operations under the EOSAT Company. Secondly, other mechanisms worked just as effectively to deny the Saddam Hussein regime from obtaining commercially available Landsat or SPOT imagery. According to John Baker and Dana Johnson, "Following the invasion [of Kuwait by Iraqi forces], the United States and France took steps [presumably through mutual consultation and negotiation] to deny Iraq access to additional imagery data from either Landsat or SPOT."[88] Third, aside from the U.S. Landsat and French SPOT systems, Russia was also marketing 5-meter film-based CRS imagery as early as 1987 through its Soyuzkarta trade association, and Iraq just happened to be a client state of Russia and might have obtained Russian imagery despite official (overt) Russian support for Coalition objectives, and especially despite a U.S. PDD, although the military utility and timeliness of KFA-1000 and MK-4 imagery would probably have been doubtful for some operations.[89] Hence, the bottom line in this example of knowledge voids is that it exemplifies incessantly myopic thinking that U.S. laws or policies have any influence over CRS imagery available from the foreign competitors of U.S. CRS satellite companies.

Department of Defense. Since 1992, when landmark legislation (i.e., 1992 Policy Act) first launched the truly CRS era, DOD's relationship with the CRS industry has been mixed. Often paying lip service in expressing its desire to support the industry, its understandable stance on national security (stemming from its perceptions that high-resolution CRS satellites imagery is a dual-use technology and could be misused by adversaries of the U.S.) has probably caused DOD to be less than aggressive in supporting the intent of Congress in its 1992 Act and President Clinton's 1994 PDD-23. Perhaps reflective of DOD's reluctance or ambivalence over warmly embracing the U.S. CRS industry in the late 1990s, Washington Post columnist Bill Gertz wrote in April 1997 that "wider distribution of this [imagery] technology brings with it potential threats that trouble the Pentagon."[90] Moreover, Gertz quoted Robert V. Davis, Deputy Undersecretary of Defense for Space, as even envisioning a terrorist group downloading a GPS-referenced image of key targets (e.g., a U.S. military base in the Middle East) and then launching a cruise missile at it.[91] While such a scenario is possible, it tends to ignore or discount the fact that such imagery could be obtained from non-U.S. CRS sources, particularly through third party purchasers and that restricting U.S. CRS imagery would not necessarily preclude such a scenario. It also assumes that adversaries possess or will possess image interpretation skills needed to identify key targets or that there are no other effective or less-expensive means (i.e., without high-resolution imagery) of targeting a particular site or object. Although Gertz did not characterize Davis as being paranoid, he did reflect the DOD official's concern over "worst case" scenarios.[92] Such concerns are appropriate when applied to efforts to develop countermeasures against such scenarios that are bound to exist as possibilities in the near future. Of course, learning curves (i.e., filling knowledge gaps) take a while to reach the optimal point and this interview with a DOD space official was less than a year since the White House's National Space Policy of 1996.

Yet Congress and the White House have made attempts to encourage government-industry partnerships and an environment in which to foster the growth of the U.S. CRS industry since the early 1990s. For example, according to the Clinton administration's policy on CRS, "the U.S. Government will….. support the development of U.S. commercial Earth observation capabilities by … pursuing technology development programs, including partnerships with industry."[93] Nearly six years later in 2002, DOD was still ambivalent. For example, commenting on NIMA's exclusive buyout of Space Imaging's satellite images of Afghanistan during Operation Enduring Freedom, retired LTG James Clapper (Director of the then NIMA) claimed DOD would not repeat that backdoor shutter control policy, as he viewed it as hurting the CRS industry. Yet in the same breath, Clapper reflected DOD's continuing uneasiness with its relationship with the CRS industry and the availability of CRS imagery on the world market. According to Clapper, "On the one hand, we as a nation, I believe, are committed to a very strong, viable, internationally dominant commercial imagery industry….on the other hand, there is understandable angst about operational security."[94]

Relations between DOD and the U.S. CRS industry over policy decisions were portrayed as somewhat hostile or unsupportive (on the part of DOD) in the early years of the Clinton administration. For example, at the 1994 Congressional hearing on CRS, HPSCI member, James Bilbray (addressing DOD witness Keith Hall), opined, "..it was normally Department of Defense, Mr. Hall, that was the holdup [for CRS license applications]."[95] The reason for the holdup and the need to come up with a concrete policy [resulting in the 1994 PDD-23] was because U.S. CRS policies, regulations, and licensing decisions were regarded by a number of administration officials as being very complex. All relevant departments or agencies were obviously suffering from being on the forward edge of a learning curve (filling a knowledge void) and apparently grappling with "extremely complex" issues, as characterized by hearing witness Robert Gallucci, Assistant Secretary of State for Political-Military Affairs.[96]

Policy complexities are not the only problem for Congress or DOD representatives; technical areas of CRS also seem to be difficult to grasp. For example, while testifying in May 1992 before a Senate committee considering the 1992 Policy Act, John Jensen, Professor of Geography at the University of South Carolina, pointed out that Senator Larry Pressler, member of the Subcommittee on Science, Technology and Space had earlier addressed Congress on February 27, 1992 that the goal of the U.S. was to maintain its leadership position in land remote sensing.[97] However, adequate knowledge of foreign CRS systems in the early 1990s would have called into question such a statement. At the time, the U.S. Landsat system was actually inferior to systems operated by Russia and France. As pointed out by Jensen, the French system (SPOT) was more advanced than Landsat in spatial and temporal resolution (i.e. revisit frequency) capabilities. To educate Senate committee members on the technical aspects of Landsat compared with other foreign CRS systems, Jensen wrote in his prepared statement that, "Basically, the United States gave up its lead in satellite remote sensing when the French launched the Le Systeme Pour l'Observation de la Terre (SPOT) on February 21, 1986 (and SPOT-2 in 1990)."[98] This technical fact is often lost on legislators and others when crafting U.S. CRS policies. In another instance less than two years later, Congressman Dana Rohrabacher, member of the House Committee on Science, Space, and Technology repeated the inaccurate view that the U.S. was technologically superior to other nations in the CRS business at the time. Rohrabacher's assertion was that "We [U.S.] are ahead in satellite technology now, way beyond our nearest competitors."[99] Rohrabacher could have been thinking of communications satellites (which are different than remote sensing satellites), but if he had read Jensen's very detailed statement submitted to the 1992 hearing, he might have realized that, technically, the U.S.'s premier land remote sensing satellite (Landsat-5) was no match for its French competitor. Landsat's spatial resolution was 30-meters, whereas SPOT's spatial resolution was 10 meters. Moreover, Landsat used an old non-pointable mirror scanning technology, whereas SPOT used more advanced pushbroom scanning technology based on charge-coupled devices.[100]

Technology-related knowledge gaps aside, Congress was still grappling with vexing CRS policy and regulatory issues well past the 1992 and 1994 hearings. Almost a decade later in 2002, Congress was still frustrated with bureaucratic sluggishness and very unhappy with the pace of the IC and DOD's purchases of CRS imagery,[101] when it "criticized the Director of Central Intelligence and Secretary of Defense for making little progress in meeting the commercial imagery goals outlined by Congress in the FY 2002 defense bill."[102] Such constant delays in drafting a CRS utilization plan could have been due to internal tensions within DOD and its subordinate agencies or due to conflicts between proponents/supporters of the U.S. CRS industry and those more concerned about the national security implications of CRS imagery availability (a cultural and perceptual dichotomy). It could also have been based on being on the forward slope of a learning curve or due to gaps in knowledge concerning the complicated aspects of a dual-use technology such as CRS. To solve the problems, Congress specifically directed NIMA (now NGA) to develop an “anchor-tenant” relationship with the U.S. CRS industry.[103]

DOD’s relationship with DOC concerning CRS licensing and foreign agreement issues is also illustrative of its relationship with the CRS industry itself. First, the degree of support that DOD lends to industry is (or has been) reflected in its role of consulting with DOC on U.S. CRS licensing applications, as mandated in NOAA’s licensing regulations. For example, in responding to a May 28, 1997 query on this matter from Congressman Rohrabacher, Cheryl Roby, Principal Director for Intelligence of the Office of Deputy Assistant Secretary of Defense (Intelligence and Security), stated during her testimony before a Congressional Hearing on House of Representatives Bill No. 1702, “The Commercial Space Act of 1997’ [which was latter passed into law as the Commercial Space Act of 1998] that the DOD-DOC relationship was evolving and involves coordination of license applications issues with several DOD-subordinate entities, such as the DOD General Counsel, Deputy Undersecretary of Defense for Space, and the Director of the Joint Staff, and DOD Intelligence components, etc.[104] During her testimony, Roby was quick to point out that DOD has been very cooperative with DOC and had approved all license applications submitted through 1997. Although recognizing the inherent risks in potential worldwide distribution of CRS imagery, Roby was astute in her acknowledgment that the CRS needed to be supported: “It was a conscious decision in the development of the President’s [1994] Policy directive, that to maintain our technological superiority U.S. industries must participate actively in the field of commercial remote sensing in space. Defense has been fully supportive of this.”[105] Yet, while continuing to voice DOD support for the CRS industry, Roby advised the House Subcommittee that many in DOD and the military were very concerned about the national security implications of CRS imagery available in the international marketplace.[106] Essentially, DOD’s perspectives (driving its relationship with or influence over the CRS industry) has been that of a balancing act – desiring to help the U.S. CRS industry but fearful of the national security implications of industries’ future satellite operations and products. On the support side of the scale, DOD assists the CRS industry through the Defense Remote Sensing Working Group (DRSWG), which was chartered on June 20, 2000 and is chaired by the Office of the Secretary of Defense (Space Policy) and includes twelve DOD components.[107] The mission of the DRSWG is to develop and coordinate DOD policies concerning CRS licensing applications and international agreements stemming from such licenses.[108]

Probably the greatest friend of the CRS industry in DOD is NGA, the DOD agency responsible, in part, for acquiring, using, and disseminating U.S. commercial satellite imagery to other government organizations. Still, at times, NGA’s relationships with industry have been mixed, indifferent, or slow to evolve, given the culture of national security within the agency. Nonetheless, NGA’s predecessor, NIMA, took a dramatic step toward supporting the U.S. CRS industry when it established is ClearView program for the purchase of imagery in January 2003 (largely prompted by then CIA Director, George Tenet). That program enabled NGA to issue multi-million dollar contracts to CRS giants, Space Imaging and DigitalGlobe.[109] The ClearView program entailed a five-year contract with each of the aforementioned CRS firms, totally $120 to $500 million in CRS imagery purchases from Space Imaging and $72 to $500 million in like purchases from DigitalGlobe, beginning with then NIMA’s fiscal year 2003 budget allocation.[110] Reportedly, this project finally systematized NIMA’s relationships with industry, whereas CRS purchases were previously on an ad-hoc basis.[111] Although highly welcomed by the CRS industry, this contract relationship placed industry in the precarious position of depending on government business to survive, instead of expanding its services into other, possibly more reliable, commercial markets. In a nutshell, the January 16, 2003 ClearView contracts awarded up to $500 million over a maximum of five years to both DigitalGlobe and Space Imaging for high-resolution CRS imagery purchases. The goal of the program was to support the U.S. CRS industry while simultaneously meeting the imagery needs of then NIMA and other USG agencies and even coalition partners of the U.S. [112] The follow-on program called NextView (contracts awarded to DigitalGlobe and Orbimage in September 2003 and 2004, respectively) allocates at least $500 million for imagery purchases and systems development incentives. DigitalGlobe also won one of those contracts, but Space Imaging lost out to its competitor, Orbimage, which won the second contract. The goal of the NextView program was not only to financially support the U.S. CRS industry, as did ClearView, but also to prompt industry into improving its satellite imaging systems and services. NextView directs industry to develop spatial resolutions in the .25-meter range and to create faster downlink technologies,[113] both needed by NGA to supplement its imagery needs.

Obviously, the ClearView program demonstrates a substantial commitment of the USG and NGA to support the still fledgling U.S. CRS industry and has been publicized extensively by media organizations tracking U.S. commercial space developments. Unfortunately, press coverage of the program and general U.S. policies regarding CRS has occasionally been flawed. For example, while researching material on the ClearView program, I came across another instance of a knowledge vacuum on these topics. According to technology journalist Frank Sietzen Jr., writing for a geospatial journal, shutter control was a DOD policy: "NIMA spokespersons were quick to point out that ClearView would not necessarily be impacted by any invocation of shutter control. This DOD policy can be implemented by the Commerce Department….."[114] Actually, shutter control is not technically a DOD policy, as evidenced by the wording of the 1994 White House Fact Sheet on PDD-23. Instead, it's a USG policy (PDD-23), and DOC implements shutter control measures based on recommendations from DOD and/or DOS. Although somewhat different, these types of perception gaps are reminiscent of Chuck Herring's (marketing manger of DigitalGlobe) comment to me in 2004 that the media is ill informed about CRS (particularly concerning its function and applications), largely believing that all it does is provide imagery for mapmaking.[115]

Still, media reps play a significant role in educating the public, and to some extent government officials, about CRS policy and economic issues, thereby serving as another actor group that socially constructs the legal and policy components of U.S. CRS technology and its operations. For example, the Radio-Television News Directors Association (a media association), contributed to CRS policy debates in Congress in 1992 and 1994 by communicating its views on CRS issues. During the 1994 Congressional hearing on CRS, RTNDA lobbied Congress to carefully consider the Constitutional ramifications of "shutter control" provisions that were then being discussed in USG interagency circles.[116] Not only can Congress or executive branch officials be potentially influenced by media organizations in a direct way, such as in Congressional hearings or other USG forums, they can also be influenced by reading media reports and journal articles on the subject of CRS policy issues (assuming they have the time). Further, even if U.S. CRS policymakers do not always consult media accounts on CRS issues, they likely consult reports and studies, which often rely on popular accounts and discussions of CRS-related issues and activities. Yet, one needs to be careful in interpreting media statements, which can often be unclear or even incorrect. For example, commenting on the ClearView program at the May 14, 2003 Commercial Satellite Remote Sensing Symposium, Warren Ferster, Deputy Editor of Space News and moderator of Panel 6 of the symposium (dealing with CRS financing issues), began his opening remarks by stating, "NIMA has indicated a willingness to invest up to $500 million over a six-year period to obtain CRS products and to foster the next generation of CRS satellites."[117] Actually, the dual $500 million contracts for ClearView was for imagery purchases only, not for future system developments. According to NGA, there is a clear distinction between the intents of the ClearView and NextView programs:

> … NextView will differ significantly from ClearView in one fundamental respect. As NGA spokesman Dave Burpee said, the ClearView contracts cover the purchases of imagery from satellites already deployed in space by the three companies [current, just two] on their own nickel. With NextView, the government is supporting new satellites while they are in development.[118]

Even though NIMA (now NGA) has been prodded into embracing the CRS industry, DOD officials (immersed in the culture of national security) have still attempted to seek legislation that would ensure sensitive but unclassified imagery data would not fall into the wrong hands. For example, in 2004 (a mere year after ClearView was established) DOD (specifically the Joint Chiefs of Staff) asked that Congress incorporate language into the 2005 National Defense Authorization Act that would restrict upper-tier CRS data from being subjected to Freedom of Information Act requests, thus keeping such data from being accessed by just anyone.[119] Upper-tier data is that which can only be sold to USG agencies as part of the conditions of a NOAA-issued CRS license.[120]

Department of the Interior. DOI plays a tricky and dichotomous role in its relationship with the CRS industry. DOI's subordinate agency, USGS supports the CRS industry by providing the backup repository for CRS imagery and has voiced its good relations with industry in attempting to accomplish its mission. Yet, there is a competitive dimension to DOI/USGS's relationship with industry. In 2001, USGS took over from NASA the responsibility for operating the Landsat-7 and follow-on systems and distributing Landsat imagery.[121] In the past, the U.S. CRS industry has been concerned about potential unfair (essentially, USGS-subsidized) competition by low-priced sales of Landsat imagery that could be met by commercial imagery. DOI's mandate (i.e., to determine which civil needs for remote sensing can be met by CRS imagery and to communicate those needs to industry) was provided by the April 25, 2003 CRSSP, which replaced PDD-23. As the lead agency for this task, USGS developed an implementation strategy in early 2004.[122] Yet, industry was initially dubious of the plan's effectiveness. In a rare moment of inter-industry cooperation, the CEO's of the former "big three" CRS firms (Space Imaging, DigitalGlobe, and Orbimage) send a joint letter (dated October 6, 2003) directly to the White House (specifically to Gil Klinger, prime architect of CRSSP), expressing their concerns that "they do not believe the plan gives the USGS sufficient authority to implement the new policy,"[123] essentially fearing that USGS's role as lead agency was not as effective as being designated the USG's executive agent for U.S. civil agency purchases of CRS imagery. Although CRSSP called for USGS to be the interface between the U.S. CRS industry and the civil government purchasers of CRS imagery, industry was concerned that the term "lead agency" for USGS's role was not as good as making USGS the executive agent for all other civil USG agencies and diluted USGS's authority in implementing CRSSP (i.e., being the clearing house for CRS imagery purchases). Moreover, a single-point agency would also have made it convenient for industry to focus its imagery sales efforts. According to R.J. Thompson, Landsat Program Manager at USGS's EROS Data Center in Sioux Falls, South Dakota, USGS's implementation plan for utilizing CRS imagery was written in a way that would not preclude other USG agencies from making direct-contact purchases of CRS imagery, rather than going through USGS and that other agencies wanted that flexibility.[124] Obviously, bureaucratic politics and turf issues came into play, even in the arena of CRS policy.

Yet clearly desirable for U.S. CRS industry and in a cooperative role (albeit not as lucrative as ClearView and NextView contracts with NGA), USGS awarded Space Imaging a one-year contract worth up to $5 million with an optional two years at the same amount, potentially totaling $15 million for the purchase of CRS imagery for other USG civil agencies.[125] Augmented by imagery from India's IRS-1C satellite systems (for which Space Imaging had an exclusive U.S. distribution agreement), Space Imaging's CRS imagery would have supported this modest USGS program by providing data to "support natural hazards and disaster response, homeland security, land and resource management, infrastructure planning and management, policy decision-making, and scientific study."[126] At that time, Space Imaging's competitor, Orbimage of Dulles, Virginia was also awarded a contract by USGS for CRS purchases with similar terms.[127]

DOI is mentioned in an interagency memorandum of understanding (MOU) as being in the coordination loop for CRS license applications. According to the January 4, 2000 Memorandum of Understanding Among Departments of State, Defense, Commerce, Interior and the Intelligence Community Concerning the Licensing of Private Remote Sensing Satellite Systems, DOC consults with DOI, in addition to other departments and the IC, when considering a decision to grant a CRS license. DOI has been tasked as the lead agency for implementing the civil aspects of CRSSP from its EROS Data Center.[128] This authority has been delegated to the USGS, which has a website that lists applicable CRS laws and policies.[129]

<u>Interagency Working Groups</u>**.** Another player on the fragmented, multi-agency remote sensing policy scene is the Remote Sensing Interagency Working Group (RSIWG). That working group is just one of three other working groups that provide input to CRS licensing and/or policy decisions (the others being NOAA's Informal Interagency Remote Sensing Working Group, the Defense Remote Sensing Working Group, ACCRES, and an IC committee on CRS licensing issues). As multiple players are added to the mix, it becomes increasingly difficult for consensus to be reached on particular CRS issues and even for the U.S. CRS industry to reach out and influence USG officials charged with the responsibility of debating, coordinating, and making decisions on CRS policies and regulatory issues. This complicated array of CRS decisionmakers is discussed in greater detail in Chapter 4.

The RSIWG is chaired by a senior DOS official in DOS's Office of Export Control and Conventional Arms Nonproliferation Policy (ECNP), Bureau of Nonproliferation.[130] As the lead interagency working group for CRS issues, the RSIWG is essentially a group of senior interagency remote sensing specialists that coordinates national security and foreign policy issues and reports directly to the National Security Council.[131] The Group includes representatives from DOD, DOS, IC, NSC, NASA, OSTP, and USGS.[132] Details of this working group were presented at a NOAA workshop on CRS licensing issues and procedures held on September 14, 2005 in Washington, DC. Reflective of yet another knowledge gap, the presentation listed six DOD-subordinate offices/agencies as being represented on the RSIWG. One of the six offices/agencies was stated to be the "National Geo-Spatial Imagery Office."[133] Actually, there is no such entity as the National Geo-Spatial Imagery Office (NGIO, if it were an acronym); instead, what was meant was the National Geospatial-Intelligence Agency, which goes by the acronym NGA.[134]

Not being familiar with the precise nomenclature of USG agencies and offices is understandable, particularly since a DOS official (possibly unfamiliar with IC or DOD organizations) gave the workshop presentation. Unfortunately, it makes one concerned about how many other aspects of the CRS policy domain are misunderstood by members of official working groups set up to coordinate foreign policy and national security issues related to the implementation of the 1992 Policy Act, CRSSP, and NOAA's CRS licensing regulations. If an organization is to be a member of a working group, the chairing organization should at least get the correct organizational name of one of its members.

While the RSIWG includes Senior Executive Service [SES]-level officials from across a wide spectrum of government agencies, the DOD has its own internal working group known as the Defense Remote Sensing Working Group (DRSWG), which was established on June 20, 2000.[135] Its purpose is to address and coordinate on all CRS issues of interest to DOD and its subordinate agencies and services.[136] It is chaired by the Space Policy Directorate of the Office of the Secretary of Defense (OSD) and includes representatives from twelve DOD components.[137]

How Do the Commercial and Public Sectors Influence Each Other?

It is the stuff of everyday politics, how agencies interact with one another. This is some of the most important, some of the most frustrating, some of the most politically motivated, some of the most necessary, and complex parts of working in federal government. And for someone trying to get a license, it can be formidable to figure out how the different agencies work with one another.

– Joanne Gabrynowicz (2000)[138]

…government policies are necessarily complex because of the multiple roles that government plays as regulator, customer, patron, and potential competitor in shaping the environment for the U.S. commercial remote sensing industry. They are also complex because of large number of government stakeholders (e.g., Commerce, Defense, Intelligence Community, NASA, NIMA, NRO, NSC, OMB, OSTP, State, USGS, and various congressional committees) that possess legitimate concerns and equities related to commercial remote sensing policy issues.

- Kevin M. O'Connell, et. al. (2001)[139]

The foregoing quotes prompt the questions: How does the CRS industry influence USG policymaking and regulatory decisionmaking? Conversely, how does the USG influence the business plans and decisions of the CRS industry? Most importantly, how does CRS technology affect government policymaking and regulations governing the operations of U.S. CRS satellites?

The emergence of U.S. companies on the CRS scene, once dominated by U.S. military space-based reconnaissance systems, has significantly impacted various arms of the USG charged with dealing with CRS issues. As CRS firms have increasingly been optimistic about their future and enthusiastically buoyed by the first two monumental documents that spurred CRS in the early to mid-1990s (i.e., 1992 Policy Act and the 1994 PDD-23), they have applied for USG licenses to build, launch, and operate earth observation satellites with GSD resolutions that increasingly approach the capabilities of U.S. defense satellites. This has caused terrific angst and concern among numerous officials in the USG, particularly in DOD, DOS, and the IC, due to the potential dual-use capabilities of CRS satellites, and has sparked heated discussions and debates about how to promote yet control the CRS industry.

The impacts of USG policymaking and regulatory regimes on the U.S. CRS industry has been enormous. Much of this is due to the fact that industry is necessarily forced to deal with multiple USG organizations to promote its interests and due to the multiple roles that the USG plays in crafting and implementing laws, policies, and regulations affecting U.S. CRS activities. These roles were highlighted in a 2001 RAND study sponsored by DOC's NOAA.[140] Many of the roles are inherently conflicting and/or potentially detrimental to the U.S. CRS industry. USG roles categorized by RAND were those of patron, customer, competitor, and regulator.[141]

The U.S. CRS industry would probably consider the U.S. Congress as its traditional patron, since it passed key legislation (i.e., Land Remote Sensing Policy Act of 1992) supporting and promoting industry's goals in developing and operating commercial high-resolution imaging satellites. Additional evidence that the U.S. Congress has been one of the best advocates for the CRS was demonstrated during the February 1994 House hearing on CRS licensing issues. In fact, Congress has often criticized the executive branch for not doing enough to support the CRS industry. As one example, Congress became very concerned (shortly after passage of Policy Act) over the delays in the executive branch in reviewing applications from industry for CRS licenses, in a timely manner. On February 9, 1994, two House committees (Science, Space, and Technology and the Permanent Select Committee on Intelligence (HPSCI)) held a joint hearing to address this issue. The daylong hearing is one of the most informative examples of how Congress shapes CRS policies and its concerns over the progress (or lack thereof) of implementing the 1992 Policy Act. The February 1994 hearing was entitled "Commercial Remote Sensing in the Post Cold-War Era" out of concern for the urgent need to develop a national policy and regulatory regime for CRS congruent with the Policy Act.

Clearly, the Science, Space, and Technology Committee, at that time, was most supportive of industry, while the HPSCI, led by Dan Glickman, tried to center itself in the controversy (i.e., between supporting the U.S. CRS industry and assuaging the national security concerns of DOD, DOS, and the IC). Essentially, the HPSCI played a middleman's role. According to Glickman, "In this area [CRS] the committee [HPSCI] seeks a middle ground between the obligations of government to safeguard national security and the needs of industry to compete in a worldwide marketplace.[142] At the outset of the hearing, George Brown, Chairman of the House Science, Space, and Technology Committee, accused the USG (i.e., the executive branch) of "preventing U.S. Industry from competing for the [CRS] business,"[143] while foreign competitors were busy trying to get into the same CRS market.

The first witness at the 1994 hearing was James Woolsey (then Director of the CIA). Representing the U.S. IC, Woolsey expressed concern over potential sales of remote sensing imagery, systems, and technology to foreign customers.[144] He acknowledged that the problem of forming an effective policy for CRS was due to competing interests (i.e., national security vs. promotion of the U.S. CRS industry).[145] In a moment of possible contention, Brown challenged Woolsey's optimism that the U.S. would soon reach a "balanced" policy as he (Brown) had heard similarly optimistic statements "for years" and he sarcastically thanked Woolsey for "his complete lack of information."[146]

Tensions between the legislative and executive branches were readily apparent during verbal sparring between other committee members and Woolsey. Reflecting the views of many other committee members, Representative Robert S. Walker of the House Science, Space, and Technology Committee (who obviously supported the CRS industry) peppered Woolsey with questions about why the CRS licensing policy was in shambles and why the current administration, particularly the national security establishment, was hindering the process of expeditious licensing of CRS firms. Very pointedly, Walker lambasted Woolsey by stating: "At the present time, your policy in the Administration is in absolute total disarray."[147]

Despite these political attacks on the executive branch by Congress, there have been agencies within DOD that have been a good patron and customer to the U.S. CRS industry. NGA is a prime example of serving industry with its ClearView and NextView programs. As for the role of competitor, USGS seems to come the closest to that description and might be considered as a slight competitor, since it is currently in charge of the Landsat-5 and -7 satellite systems which produce imagery and distributes it to various sectors that industry might like to serve (e.g., the scientific community, for example). However, the imagery from these civil earth observation satellites is of medium resolution and thus only impacts slightly on the CRS industry.

The final organization that has an impact on the U.S. CRS industry as its regulator is DOC's NOAA. With the mandate to draft CRS regulations, NOAA published its first set of draft regulations in November 1997, over five years from the passages of the Land Remote Sensing Policy Act and three years from the issuance of PDD-23. After receiving public comments on the proposed regulations, NOAA finally issued a final set of interim regulations in July 2000 (based on public comments and interagency coordination), with a time lapse of over six years from the date of PDD-23 (the base policy for the regulations).[148] The final set of regulations were issued in April 2006, which was an incredible 12-plus years since NOAA was tasked to write the U.S. CRS regulations.

Conflicts and Collaboration: Significance of Knowledge and Perception Gaps (Effects on Legislation, Policies, and Regulations)

Conflicts of Interests and Perceptions in the CRS Policy/Regulatory Environment

The political history of U.S. CRS has been fraught with significant conflicts of interests and divergent perspectives, but has also shown hopeful signs of collaboration and cooperation. Yet, knowledge and perception gaps, often driven by divisive issues such as national security, information transparency, and economic competitiveness, have played a tremendous role in political and bureaucratic conflicts associated with U.S. CRS satellite systems and their capabilities. As part of the human component of the technological systems of earth observation satellites, knowledge and perceptions are fundamental to crafting and implementing CRS legal regimes and control mechanisms embodied in government regulations.

Numerous STS studies have attempted to show how technologies (which include laws, policies, and regulations as so adeptly described and argued by Thomas Hughes in his large technological systems concept) are shaped by institutional and organizational cultures, interests, and perceptions. These factors are very important in understanding how technologies are shaped by society. The argument that perceptions, and especially knowledge gaps, shape U.S. CRS legislation and polices is an extension of these STS theories, showing how institutional cultures and perceptions have consequences for the accurate exchange of knowledge. This factor has not been adequately addressed in the existing literature on U.S. CRS policy. Here, it is important to realize that institutional cultures can contribute to both perception gaps and knowledge gaps concerning CRS policy issues.

Although samples of knowledge gaps on U.S. CRS issues were introduced in Chapters 1 and 2 to provide an analytical window through which to view, understand, and analyze how such gaps or voids affect CRS policymaking, this section attempts to provide more evidence of the interplay between lack of deep understanding of the highly complex issues surrounding U.S. CRS activities and USG attempts to control and regulate them. Here, I focus on what I would term micro-knowledge voids, or isolated examples of inaccurate understanding of the complexities of U.S. CRS laws, policies, regulations, economics, and technological capabilities. In Chapter 4 (concluding chapter), I transition from a micro view to a macro view on how knowledge gaps affect the politics of CRS satellite systems and operations and how they potentially underlie divergent viewpoints and policy perspectives on how best to support the CRS industry while simultaneously protecting the national security and foreign policy/obligations of the United States.

Throughout the history of U.S. CRS policymaking, DOC seems to have been caught in the middle of executive branch conflicts, wrangling, and indecisions over how to deal with the new law on CRS thrust upon them in 1992. The 1992 Policy Act mandated that DOC be the responsible department for reviewing and granting licenses to U.S. firms interested in launching and operating CRS systems. DOC had its share of problems in implementing the Act, although to be fair, much of the delay can be attributed to the slow policy coordination process endemic in the bureaucracy of the USG.

Knowledge gaps have also been a problem and undoubtedly lead to bureaucratic conflicts and indecision on how best to implement PDD-23 and, later, the CRSSP of 2003. For example, during the 1994 Joint Committee hearing on CRS, then DOC Under Secretary for Oceans and Atmosphere, James Baker, stated that DOC had complied with the 120-day licensing deadline by notifying an applicant (Lockheed) that DOS was requesting a delay until a unified administration policy was in place. In Baker's words, "…we [DOC] are prepared to go ahead and make a decision, but the State Department has asked us, and we are required by the 1992 Act to abide by those conditions to have a unified Administrative policy on this issue."[149] Here, exemplary of a huge knowledge void (this time by a senior administration official of DOC), this contention was totally erroneous. Although purely speculative, it is always possible that Baker was very familiar with the law but interpreted its overall or implied intent to suggest this unified administration policy (which would have been PDD-23) or that he wanted an excuse to delay action. Still, nothing in the 1992 Act states such a condition (i.e., unified administration policy). In fact, even Norman Dicks, HPSCI member, challenged that assertion and knowledge void, stating: "But that isn't exactly accurate. I don't think, if I read this correctly."[150] Since neither of them seemed intimately familiar with relevant provisions of the Act, a quick review of the law is warranted. Nothing in the Act specifies a "unified Administrative policy." The only closely relevant provisions of Subchapter II (Licensing of Private Remote Sensing Space Systems) of the Policy Act are as follows:

> Section 5621. General licensing authority. (a.1.) In consultation with the appropriate United States Government Agencies, the Secretary [DOC] is authorized to license private sector parties to operate private remote sensing space systems for such period as the Secretary may specify and in accordance with the provisions of this subchapter.[151]

> Section 5621. General licensing authority. (c.) Deadline for action on application. The Secretary shall review any application and make a determination thereon within 120 days of the receipt of such application. If final action has not occurred within such time, the Secretary shall inform the application of any pending issues and of actions required to solve them.[152]

Although other provisions of the Act required the Commerce Secretary to consult with the Secretaries of Defense and State regarding national security and foreign obligations issues or related conditions for licensing, the entire Act does not mention anything about this mythical "unified Administration policy." It was simply reading more into the law than what was explicitly stated therein. Such a policy only came about as a result of PDD-23, issued shortly after the February 9, 1994 hearing, even though it had been discussed in interagency forums leading up to that Clinton Administration policy. PDD-23 reiterated DOC's responsibility to review license applications in accordance with the Policy Act (which specified that DOC would consult with other government agencies on such applications) and specifically mentions DOS's and DOD's role in recommending to DOC the imposition on "shutter controls," when necessary (see Appendix B and C for relevant provisions of the Policy Act and PDD-23, respectively).

Testimonies provided to the 1994 Joint Committee hearing (in what could be called a pre-PDD-23 period), represented the views of the DOC (James Baker, Under Secretary for Oceans and Atmosphere), DOD (Keith Hall, Deputy Assistant Secretary for Intelligence), and DOS

(Robert Gallucci, Assistant Secretary for Political-Military Affairs), all political actors or representatives of the executive branch. A general theme voiced by these administration officials was the tremendous complexity of CRS policy and issues. DOS representative Gallucci provided a brief account of the competition issues of industry, national security, and foreign policy concerns over CRS imagery distribution, particularly those issues that impact the mission, functions, and activities of DOS. Like others, he recognized the extreme complexity of these issues, stating: "As you can see from this brief outline of some of the competing factors, this issue is one of immense complexity…"[153] This was also well portrayed during the hearing by Scott Pace of the Washington, DC office of the RAND Corporation, who summed up the complexities of CRS policies and licensing issues:

> The issues of remote sensing, I think, in many cases have gotten confused with all sorts of other issues such as release of declassified imagery, the future of the LANDSAT program, what's happening with remote sensing, proliferation – there's all sorts of complex issues that are involved here, and I don't want to take away from that sense of complexity.[154]

As argued throughout this dissertation, the complexity of CRS policy issues, as reflected in Pace's statement, takes it place among other factors as the basis for CRS knowledge voids. The more complex a policy issue, the more one needs to comprehend the multiple and relational dimensions of such issues, to arrive at policy decisions that support one's stated goal (in the case of U.S. CRS, promoting a viable CRS industry).

In setting the stage for the crafting of policies and regulations governing the licensing and operation of CRS systems, each witness in the 1994 hearing promoted the interests of their own particular department, but all voiced the mantra of the desirability of striking a balance between CRS industry growth and protecting U.S. national security and foreign relations with other countries. Interestingly, when questioning Mr. Hall of DOD, HPSCI Chairman Glickman voiced a common but debunked STS theme when he asserted something along the lines of technological determinism. Commenting on transfers of sophisticated CRS systems and technology to foreign entities, Mr. Glickman stated, "The technology improvement is kind of – part of a natural law [perhaps referring to the debunked notion of technological determinism and ignoring the social inputs to technological growth]."[155] Often during difficult questions, administration officials (i.e., witnesses) would either express knowledge gaps, point fingers, engage in double talk, or simply pass the buck. The latter action is easy to accomplish when there are so many people and agencies responsible for formulating CRS policies and regulations and making licensing decisions. In addition to DOC, DOD, DOS and the IC, even OSTP and the NSC play a role (particularly, the latter two when it comes to resolving licensing and shutter control issues). For instance, when DOC reaches an impasse with DOD and DOS on licensing and shutter control issues, it refers the matter to the President's Assistants for National Security and Science and Technology for ultimate resolution by encouraging interagency consensus or ultimately referring the decision to the President.[156]

Another recognition of knowledge gaps during the 1994 hearing was voiced by Anna Eshoo, member of the Science, Space and Technology Committee, when she asked the government witnesses, "when was the last time the deputies [meaning the Deputy Secretaries of each Department] came together from the various departments with the discipline to move on this [i.e., decisions on CRS licensing applications]?"[157] After a pause and eliciting no response, Ms. Eshoo remarked, "Well, you don't remember, so it couldn't have – that was a really tough question, I'll tell you. Stumped the brains."[158]

Knowledge gaps also seem to abound in the media or even in government agencies such as NOAA, the organization tasked by DOC to draft and execute regulations for licensing and operating CRS satellites. For example, a May 1999 report quoted a DOC official, Charles Wooldridge, NOAA's remote sensing licensing coordinator, as stating that as Space Imaging's 1-meter GSD-capable Ikonos satellite was about to be launched, "…NOAA would re-evaluate matters such as the Israeli 1-m exemption and other regulatory issues."[159] Although Wooldridge could have been misquoted (in the spring of 1999) in the International Society for Optical Engineering (SPIE) report, the restriction stemming from the Kyl-Bingaman Amendment, was interpreted by the USG to be 2-meter, not 1-meter GSD resolution (a big difference). According to Gerald Steinberg, professor of politics at Bar-IIan University in Israel, the original limit of 1-meter was revised to 2-meters in July 1998 (almost a year prior to the SPIE report and Wooldridge's comments), which essentially "blacked out Israel at resolutions below 2 meters."[160]

To reiterate how confusing the laws and policies on CRS resolution are to numerous individuals dealing with CRS issues, another knowledge gap was detected in a fairly recent (February 2004) presentation to a conference entitled "U.S. Space Operations in the International Context". Speaking on the national security issues of CRS, Theresa Hitchens, Vice President for the Center for Defense Information, stated, "Congress in 1996 passes an amendment [likely meaning the Kyl-Bingaman Amendment] which prohibited the sale by U.S. firms of images of Israeli territory at less than two-meter resolution."[161] Actually, the amendment (two short paragraphs) revealed no such mention of 2-meter resolution constraint . All the amendment specified was that a license can be issued and imagery declassified and dissemination for satellite imagery related to Israel, only if it "is no more detailed or precise than satellite imagery of Israel that is available from commercial sources."[162] The confusion with this language (or lack thereof) most likely comes from the report of the Senate proceedings concerning Amendment No. 4321, wherein 2-meter-quality CORONA imagery, releasable per Executive Order 12951, was mentioned as a concern for the security of Israel.[163]

To point to all of these CRS-related knowledge voids is to demonstrate that CRS policy issues are quite complex and involve multiple knowledge domains and that lack of complete and accurate knowledge of the subject can complicate the policymaking process. While individual knowledge voids might not necessarily impact effective CRS policymaking, an amalgamation of such voids (discussed in Chapter 4 as structural or categorical knowledge voids) can hamper informed debates on CRS policies or lead to ineffective CRS rules and policies. Of course, complexity is not the only determinant of knowledge voids; institutional cultures can also lead to actual or contrived knowledge gaps concerning CRS policy issues. In the case of the latter, passing the buck or selective memory losses can be good excuses for not dealing with or delaying the resolution of complicated policy issues. Of course, even if one has better information or knowledge on a particular policy issue, one could always delay action on that issue because one's perception stands in opposition to a proposed policy position (e.g., relaxing or eliminating shutter control regulations). Here, we might encounter a tendency to put off or ignore a difficult policy decision because of strongly held policy perceptions. This is likely one of the reasons (coordination bickering) for delayed CRS licensing decisions in the 1990s.

Institutional cultures are the shared beliefs, attitudes, and practices of established socio-political organizations. While much has been written in the STS literature about institutional cultures shaping perceptions and beliefs, the relationship of institutional cultures to defective knowledge is not as apparent. This raises the question: How do CRS stakeholders' institutional cultures shape one-sided knowledge domains and contribute to knowledge gaps concerning CRS policy issues? Here, contrasting the two primary CRS stakeholder cultures, termed the "merchants' and the "guardians" by Scott Pace (see Chapter 1), is instructive. In the case of the merchants or the CRS industry, the organizational culture embraces profitability, economic competitiveness, and providing a product or service with high demand. Thus, it is not a far stretch of imagination or logic to assume that executives within that culture would tend to focus their knowledge-accumulation efforts on bolstering their expertise (know what) and competencies (know how) deemed valuable by their companies. While engaging in and learning the CRS policymaking process is important for these individuals, making their CRS companies succeed financially would be of more immediate concern when prioritizing the time one has available in acquiring various knowledge assets.

When it comes to the "guardians" of USG institution involved in national security and foreign policy issues (DOD, IC, DOS, NSC, etc.), the relationship between institutional culture and knowledge defects is even more salient. Assuming the culture (shared beliefs and practices) of the institution of the guardians is protecting against any misuse of CRS imagery to threaten the defense and foreign policy interests of the U.S., then it is not a significant leap of logic to assume that such institutions would provide massive amounts of information or knowledge gained through training or actual work on the job (e.g., staff work) skewed towards security objectives and thus not leave much time or incentive to acquire knowledge about the economic aspects of CRS (deemed valuable by the CRS industry in determining effective CRS rules and policies).

Potentially, an even more persuasive explication or analysis of the relationship between institutional cultures and CRS knowledge voids can be made concerning a third important stakeholder in CRS – the legislative branch of government. The culture of Congress dictates that its members respond to its constituency if they want to get reelected. Although interest groups and lobbyists play a significant role in influencing Congressional actions, U.S. legislators tend to focus their knowledge accumulation efforts in areas that they deem are important to the electorate (public), which would most likely be hot-button issues of the day vs. the esoteric field of CRS. Again, this institutional culture that promotes serving one's constituents (and most of them are not familiar with or interested in CRS policy issues) indirectly and inevitably contributes to knowledge gaps on the subject due to lack of time or interest in gaining the requisite knowledge to fill those gaps.

Admittedly, institutional cultures are a very complicated subject and these assertions are at best broad and surmised generalities that knowledge voids are shaped by interests or mindsets of specific policy actors. More research would need to be undertaken to more fully analyze the theoretical relationship between institutional cultures and knowledge voids and such would be a fruitful project for future STS studies as discussed in Chapter 4. At this juncture, it is important to recognize that knowledge voids are not always neutral, as the foregoing argument demonstrates. Although only a speculative observation, institutional cultures associated with any form of CRS policymaking could be viewed as encouraging what I call “contrived” knowledge voids. Buck-passing or selective memory lapses could be blamed on a culture that resists criticism, often characterized as “risk aversion” in the national security community (DOD, IC, DOS, NSC, etc.) and thus lead to representing one’s self as not completely knowledgeable on CRS, or even worse, purposefully making inaccurate knowledge claims.

Although a stretch, one could view the non-neutrality of the social construction of CRS knowledge gaps as akin to the deliberate social construction of ignorance. Abolishment of the OTA might serve as one example of the intentional removal of a knowledge-creating entity within Congress. During its existence, OTA provided a substantial amount of knowledge to Congress in 1982 and 1984 concerning the problems of commercializing the Landsat system.[164] Unfortunately, the elimination of OTA removed a valuable source of information on many S&T issues, not just civil remote sensing or CRS. Although the history of OTA is complicated, one of the main reasons for its demise was stated to be fiscal austerity,[165] strikingly similar to the same motivation of the Reagan administration for commercializing the Landsat program.

Additional Examples of Policy Conflicts and Related Knowledge Gaps

On the tails of the George W. Bush administration’s 2003 CRSSP issued on April 25, 2003, a symposium jointly hosted by DOC (NOAA), NASA, and the USGS was held in Washington, DC on May 13-15, 2003. In his opening remarks at that symposium, Gregory Withee, Assistant Administrator for Satellite and Information Services, NOAA, hailed a new era of cooperation between government and industry, particularly in the expanded government role in purchasing CRS imagery (e.g., NIMA’s ClearView contract).[166] Although some government perspectives on collaboration in CRS activities were unsurprisingly positive, one representative of industry had a completely different perspective. John Curlander, CEO of Vexcel Corporation (a multinational remote sensing technology company), made a most salient observation as a symposium panelist addressing CRS cooperation and collaboration issues. In his opening remarks on May 15th, Curlander commented on the historical relationship between the CRS industry and the USG and characterized the early days of such relationships as strained or hostile. In an excellent portrayal of this historical relationship between government and the CRS industry, Curlander stated:

> Historically, this [CRS] industry has had a very strange relationship with government. In the early days of the industry, commercial remote sensing was seen as a threat to government, and to some extent, the government is still fighting us [i.e., industry]. The US government cannot control CRS–the technology is out there and people overseas have it. Now that imagery is universally available, the government finds itself in a tug of war between security and the health and viability of the commercial industry. … It could take 5, 10 or 15 years for the government to completely shift gears, …...”[167]

Another way that knowledge gaps (underlying imprecise knowledge claims) can potentially contribute to USG policies unfavorable to the CRS industry is through the spread of inaccurate information on foreign CRS systems and their capabilities. This is because the USG needs accurate information on foreign CRS systems to implement its CRS laws and regulations. Such laws and have placed constraints on U.S. systems based on the capabilities of foreign earth observation systems. For example, the Kyl-Bingaman Amendment to the 1997 Defense Authorization Act prohibited imaging of Israel at resolutions greater than that offered by any other nation's remote sensing system at the time. Although the language of the Amendment did not specify a precise resolution limit in meters, the U.S. agreed in July 1998 to a 2-meter limit, [168] presumably because the Russians were offering CRS imagery at 2-meter GSD resolution to foreign consumers of its imagery products.

In a more favorable tone, the 1994 PDD-23 specified that U.S. CRS operating licenses would likely be granted for systems that were commensurate in resolution capabilities to existing and future foreign CRS systems. According to a White House fact sheet on PDD-23, "There is a presumption that remote sensing space systems whose performance capabilities and imaging quality characteristics are available or are planning for availability in the world marketplace will be favorably considered,…"[169] To comply with this language, NOAA would need to know the current and near-future imaging capabilities of foreign CRS systems. Foreign CRS systems are like moving knowledge targets and need to be accurate and frequently tracked to prevent these types of knowledge gaps from being communicated by individuals or organizations attempting to educate USG legislators and policymakers. Unfortunately, current and future foreign CRS satellites can create substantial competition for U.S. CRS firms and the capabilities of these foreign systems are often lost on U.S. policymakers and regulators. Moreover, technological aspects of U.S. and foreign CRS systems, and their impacts on U.S. policies and regulations, are often misunderstood. This can lead to faulty perceptions in attempts to balance the economic viability of the U.S. CRS industry with national security and foreign policy concerns of various departments and agencies of the USG.

One of the deepest knowledge voids concerning U.S. CRS policies that was identified during research for this dissertation was the widespread lack of familiarity (among CRS policymakers and the CRS industry**)** with foreign satellite systems capable of providing commercially available imagery on the global market. As stated in Chapter 2, technical descriptions of CRS satellite imagery can be confusing and problematic. Perhaps another example of this unfamiliarity with foreign systems was demonstrated in the formative years of U.S. CRS. Specifically, a technically inaccurate (but conceptually simplified mathematical) statement was noted in the prepared statement of Walter Scott, CEO of WorldView Imaging Corporation, who testified before Congress in February 1994. According to Scott, World View's planned CRS satellite imagery, which would have a 3-meter resolution capability, would "offer resolution that is 3x-10x better than any commercial imagery available today,…"[170]

Contrary to Scott's assertion, Russia was providing 2-meter panchromatic (analog film-based) satellite imagery through its commercial outlets in the early 1990s, and ironically, the photo on the wall at the 1994 Congressional hearing (captioned "Commercially Available Satellite Imagery From Russia,)[171] showed it as having a panchromatic resolution of 2 meters. A 3-meter system would be worse, not three times better than a 2-meter system; thus World View's statement was completely inaccurate. Russia's State Scientific Research and Production Center (Priroda) was licensed by the Russian Space Agency in 1993 to market imagery products with up to 2-meter resolution.[172] Although the photographic imagery derived from Russian military satellites (i.e., Resurs F-3) was even better than 2-meters, it had to be degraded to 2-meters or greater due to Russian federal government policies and directions at the time.

It is possible that Scott was discounting the better Russian imagery (since it was only film-based imagery derived from military satellites and the Russians offered no MSI comparable to WorldView's 15-meter projections). Most likely, Scott was referring to the French SPOT-1 and -2 systems offering 10-meter resolution and the U.S. Landsat-4 and -5 systems offering 30-meter resolution. Using a base of 3-meters (for the WorldView satellite) one might think that 3 meters is about 3 times better than 10 meters and 10 times better than 30 meters. However, the flaw in this conceptualization is that image resolution entails a squaring function and thus 3 meters would actually be about 10 times (technically 11.11x) better than the SPOT systems and 100 times better than the Landsat system (a huge difference, especially for the "~10x" declaration). In this case, the faulty knowledge conveys resolution as a linear function, not a squared function. Thus, if comparing the French and U.S. systems, respectively, the WorldView statement should have been "11x~100x better." Appendix F offers a more detailed description of spatial resolution differences based on this example.

Communicating imprecise knowledge is misleading and creates deeper knowledge gaps among the information recipients, particularly concerning resolution factors and differences between them. Here, the most instructive point is that the misinformation in WorldView's statement was not just simply given off the cuff, but was actually contained in a prepared written statement submitted to the Congressional committees. Still, stating the resolution comparisons in mathematically correct terms might also have confused the committee members and other witnesses, as well. Nevertheless, one doesn't necessarily have to be an expert in space imagery to know that spatial resolution changes and comparisons of them are a function of squaring. For example, exhibiting precise knowledge of resolution differences, Leonard Spector (a writer on nuclear proliferation issues, but not a remote sensing or photogrammetry expert) wrote back in 1990 or earlier that the difference between SPOT and Landsat imagery (i.e., 10 meters vs. 30 meters) was a "nine-fold" improvement in the direction from Landsat to SPOT.[173] At the time Spector was a senior fellow at the Carnegie Endowment for International Peace and was formerly with the Department of Energy.

Also reporting on the rampant confusion over resolution differences in CRS policy discussions, Ben Iannotta succinctly but accurately clarifies the confusion (knowledge voids) by quoting Thom Goertel of Autometric, a Springfield, Virginia, during a 1999 interview. Paraphrasing Goertel, Iannotta reports, "The difference between 1-m and 2-m resolution does not sound like much, but the terminology is deceiving, says Goertel; 2-m^2 images actually consist of four identical 1-m^2 blocks.[174] [citation continues] As Goertel stated, "So 1-m resolution isn't twice as good as 2-m – it is four times better."[175]

Scott is not alone in being affected by knowledge voids concerning CRS, particularly the imagery capabilities provided by other nations in the 1990s to the early 2000s. Many authors of CRS topics seem to be very unfamiliar with Russian capabilities in the CRS imagery arena. For example, commenting on the quality of Space Imaging's Ikonos satellite as being 1-meter (panchromatic) and 4-meter (multispectral) – a correct statement – Marco Caceres wrote as late as September 2000 that "The best quality available up until Ikonos 1B [launched in 1999] was

[India's] IRS-IC's 5.8 m,"[176] yet the Russians were selling 2-meter imagery on the open market in the early 1990s, as evidenced by previous citations in this dissertation. As additional evidence on statements driven by knowledge voids, Richard Davis wrote back in 1992: "The highest resolution available currently is provided by the Former Soviet Union which launched a satellite with five-meter resolution in the fall of 1996."[177] Five-meter resolution beats 5.8-meter resolution (i.e., the Indian IRS-IC), but even more damaging to these types of ill-informed statements is the fact that the Russians were actually marketing 2-meter resolution imagery by 1992 as previously mentioned and referenced in Chapter 2.

Environment of Collaboration and Cooperation

Even though conflicts over CRS policy issues have been rife during the short history of U.S. CRS (in part, driven by perception and knowledge gaps), there have been cases of cooperation between the CRS industry and the government, particularly in the purchase and use of imagery or the joint utilization of CRS satellites. For example, Orbimage's Orbview-2 (Seastar), launched in 1997, carries a NASA sensor called the Sea-Viewing Wide-Field-of-View Sensor, which supports NASA's Earth Science Enterprise (ESE) program. Part of the ESE program allows NASA to act as an mediator or broker between the CRS industry and academia (i.e., earth science researchers).

Expounding on the vision of the ESE program and its intent to cooperate with and bolster the CRS industry, David Brannon, NASA's Program Manager for ESE's Commercial Remote Sensing Project (CRSP), testified in September 1998 before Congress (Subcommittee on Basic Research) that his organization would encourage earth scientists to request CRS data for their research projects.[178] During the same 1998 hearing, Scott Pace testified that CRS data was valuable for NASA's ESE program and encouraged cooperation between the public (NASA as lead) and the private sector (CRS industry).[179]

According to O'Connell and Hilgenberg, NASA's CRSP attempted to accelerate "the development of the U.S. remote sensing industry, creating mutually beneficial partnerships between ESE scientists working with NASA and the remote sensing industry, and making NASA a good customer for the U.S. remote sensing industry."[180] Unfortunately, the SDB project – a key component of the CRSP, was short lived. However, another component of NASA's CRSP is its Earth Observations Commercial Application Program (EOCAP), which aims at filling knowledge gaps covering the value of CRS with the geographical information (or GIS) industry and, as such, has "created cooperative relationships"[181] with the CRS industry. According to Brannon, NASA's EOCAP program assists the burgeoning CRS industry by promoting applications for national needs such as "environmental assessment and monitoring, infrastructure planning, natural resources management and disaster management."[182]

Both NASA's SDB and EOCAP programs have been examples of government-industry cooperation that have helped the CRS industry, but they have only been funded in the tens of millions of dollars - a far cry from what industry needs to survive in the highly competitive global marketplace for CRS imagery products. Nevertheless, the program has provided the CRS industry with ideas and applications that could help it gradually diversify its markets away from massive government patronage in the form of imagery purchases for national security purposes.

Social Construction of Knowledge Voids and Their Implications for CRS Policymaking

Are knowledge voids socially constructed? Individual knowledge voids concerning CRS have been documented extensively throughout this study. Such individual knowledge defects become group or institutional knowledge voids (i.e., are socially constructed) when knowledge void indicators are repeated and propagated among groups or institutional environments and when such knowledge voids (although factually unfounded) support or bolster the interests and cultural practices of particular CRS stakeholder institutions. The social environment of these organizations influences what people know because members of U.S. CRS stakeholder institutions have priorities for acquiring knowledge and those priorities are skewed toward what they need to know to meet their organizational objectives. Moreover, groups of individuals (many but not all members of institutions) tend to embrace the beliefs and perspectives of their organizations (e.g., security concerns in the case of the "guardians") and they could be seen as generally tending towards only being interested in seeking knowledge that supports their organizations' missions, objectives, and professional interests.

As mentioned in this study, there are numerous reasons for knowledge voids that influence perceptions and ultimately policy decisions. Table 3 depicts a variety of common knowledge voids that have an effect on the politics and policy aspects of CRS (and potentially other S&T-related policy areas). They have been grouped into broad categories to describe their probable causes and policy impacts. Rows are color-coded to show knowledge voids that are closely related or that can be placed into broad categories. These knowledge voids were selected to highlight the issues of lack of knowledge in CRS policymaking and to help one develop strategies and techniques for dealing with or reducing them to promote a more informed environment of CRS political (legislative) and policy decisions.

TAXONOMY OF KNOWLEDGE VOIDS (KVs)

Type	Description	Remarks/Examples	Potential Policy Impacts
Complexity-based KVs	Difficult to understand info (esoteric fields outside one's area of specialization). Numerous and inter-relational knowledge components.	Technical data, legal/policy details, economic and international aspects of CRS (could take years or decades to learn).	Increased role for or reliance on experts; little public involvement. Possibility of leading to technocratic advice or institutions; few inputs from non-experts.
Low Competency KVs	Lack of experience, specialized training, or capacity to acquire a particular knowledge set.	Position turnover resulting in placing one at the bottom of the learning curve due to lack of initial competency.	Staid and outdated policies seldom change, Difficult environment for informed policy debates.
Info Glut KVs	Overabundance of data and info on a topic or field leading to difficulty in determining what part of the knowledge spectrum is important.	Massive amounts of data and info in CRS (all dimensions) that need to be surveyed and summarized for key policymakers (but needs manpower and expertise to do so).	Possible role for technology"translators" (rebirth of OTA?) to simplify key ideas for lawmakers. Translators could include industry, spokespeople, research institutes, science journalists, etc. Role for popularization of S&T.
Politically/ Ideologically-motivated KVs	Knowledge available but untapped or unused due to other agenda-driven interests or avoided altogether due to conflicting perspectives.	CRS policies directed toward privatization of Lansat program in 1984 to optimize particular political agendas. No pressure from constitutes to learn an issue from an opposing stance.	Ideologically-driven policies divorced from technical or economic realities or consequences (in CRS, thwarts or detracts from primary stated goals of the USG).
Avoidance/ Deliberate KVs	Refusal to assimilate new info or knowledge because it "clutters the brain" or is perceived to be not useful. Suppressing info that could be used in policy issues. Deliberate KVs include those caused by secrecy (similar to knowledge barriers).	Similar to politically-motivated KVs. Fear of being exposed to any new knowledge that could alter one's perspective, opinions, or beliefs. Knowledge is avoided or ignored because it might changes one's mind and one doesn't' want it to be changed.	. Policy decisions may never get made or are excessively delayed. Pass the buck "syndrome." Results in over reliance on outside expertise without internal double-checking.
Parochial KVs	Knowledge deficiencies due to <u>focusing on particular knowledge domains</u> at the expense of other knowledge domains. Also included in this category are KVs due to lack of interest.	National security/foreign policy community focusing on CRS imagery threats vs. being focused on economic/competitiveness aspects of CRS to assist or bolster industry.	Balkanized agencies, each pursuing their own agendas, Inefficient or exclusionary policies due to organizational missions that focus on particular knowledge domains to the exclusion of other knowledge domains
Priority-driven KVs	Not enough time. Too busy focusing on interest or organizational missions.	Acknowledging that new knowledge needs to be acquired but not having enough time to do so. Busy schedules and demanding work or knowledge acquisition workloads.	Tendency to take only one side of a policy issue due to lack of knowledge or appreciation of the other side.
Info Inaccessibility KVs	Info exists but is not accessible except for authorized individuals. Info that is not readily available in the U.S. or via the Internet.	Classified/restricted USG info; proprietary info in industry; foreign sources: unavailable or inaccessible data and information (in English) even via the Internet.	May result in policy decisions that could be harmful or counterproductive due to absence of critical information needed in policy debates/discussions.
Language Barrier KVs	Info in foreign languages needing competent translation. Lack of translators with S&T background (for CRS).	CRS laws, policies, regulations, marketing plans, technical data, etc. exists but are not readable due to being in a foreign language (often outside Europe or English-speaking countries).	U.S.-centric policies, blindness to key international issues. Possibility of detrimental policy decisions with domestic or international ramification. Lack of opportunity to learn foreign ways of doing things that could be instructive.
Combination KVs	KVs caused by a combination of one or more other categorical KVs (most likely the norm).	The most difficult KVs to reduce due to multiple causative factors or not knowing which factors are most contributory. Can be characterized by the statement: "I dong' know, I don't care, it's too difficult to learn, and it won't make a difference, anyway."	Possibly the most problematic for policy issues due to a combination of many other policy impacts enumerated above in this column.

Table 3 - Common Knowledge Voids (Descriptions, Causes, and Policy Implications)

In the case of CRS, socially constructed knowledge voids could be defined as those that are shared by numerous individuals or groups grappling with complex CRS policy issues. They generally constitute macro knowledge voids because they reflect bad information or lack of understanding of broad categories of CRS issues. Such knowledge gaps can be constructed by a single individual but then propagated throughout the CRS literature and other information mediums that are consulted and used by CRS stakeholders or other actors in the CRS policy arena. The social forces that go into constructing faulty perceptions on the major issues of CRS consist of elements within the USG (Congress and executive branch agencies). They also consist of outside observers who are interested in or study CRS policy issues that do not identify or deconstruct false knowledge claims that lead to faulty perceptions, such as the need to place restrictions on U.S. CRS systems to protect national and international security when foreign CRS systems will just fill the CRS technology void.

An example of socially constructed and propagated knowledge voids (or inaccurate facts and information on CRS issues) is the heretofore discussed 1-meter resolution myth. Another example of socially constructed CRS knowledge voids is lack of awareness of, or interest in, CRS by the general public, which is then transferred to US legislators or policymakers who spend little time learning the myriad aspects of U.S. CRS, unless pressed or compelled to do so. Such constructions are not the same as those discussed by SSK, social construction, or SCOT theorists. Their concept of social construction generally applies to the creation and utilization of facts and artifacts. Although closer to SSK, my knowledge void concept (as applied to CRS policy) looks at the problem from an opposite direction. Instead of analyzing how facts are constructed, it identifies manifestations of non-facts and then attempts to deconstruct them by determining their probable causes. Rather than unintentionally disseminating inaccurate information, if CRS stakeholders or observers study and disseminate accurate information about CRS, they contribute to filling knowledge voids – a social activity in this case. Unfortunately, these academic or information-gathering and analytical activities do not occur often enough due to lack of interest, competency, and most especially, funding by Congress or executive branch agencies and such inaction constitutes a form of social construction of CRS knowledge voids. This does not mean that Congress and the administration deliberately keeps the public in the dark about CRS policy issues (although some might argue this is potentially the case based on knowledge dominance and boundary-protection theories discussed in STS). Instead, the lack of public awareness of CRS and other complex S&T issues stems (in part) from the current culture in the U.S. (and probably other nations) of what some have called the "dumbing down" of American education and lack of S&T astuteness due to the popular media/culture and substandard pedagogy in our pre-university academic institutions. Much has been written about the dearth of math, science, and engineering competency among the general population (and youth) and shortages of skilled math and science teachers in our primary and secondary educational institutions. Unfortunately, such a social environment contributes to S&T ignorance, but more problematic is the media culture that promotes mindless avenues of diversion and recreation in the form of books, magazines, movies, video games, and TV shows that seem to concentrate on entertainment value vs. educational value. Sports and pop culture are often portrayed as more glamorous than S&T pursuits.

Social constructions of CRS can also be viewed as a competitive dynamic; CRS capabilities, activities, applications, and users are determined to a great extent by the manner and form in which U.S. CRS laws and policies are crafted and implemented and those social constructs are influenced by competitive forces. Specifically, the major duality of competitive perspectives that shape U.S. CRS control regimes is that of national security vs. information transparency and openness. As social constructs, each of these competing perspectives intentionally or inadvertently creates knowledge voids concerning the political and policy dimensions of U.S. CRS. This phenomenon occurs when national security stakeholders create and disseminate compelling but imbalanced knowledge on the potential threats of CRS. In doing so, they present their side of the case filled with facts, information, and viewpoints on the security implications of U.S. CRS, but leave out the socio-economic and scientific benefits of CRS imagery and how impeding the CRS industry (through restrictive CRS policies and regulations) potentially detracts from those benefits.

Conversely, touting the benefits of CRS imagery to mankind and that concerns over the national security and foreign policy implications of CRS activities are overblown runs the risk of not providing knowledge on the actual risks that CRS imagery can pose to U.S. national security and foreign policy interests and those of its allies. Yet, in this process of socially creating knowledge voids (about facts that do not mesh with one's policy perspectives), it is the information and openness camp that is handicapped because it does not have access to non-public and restricted information on such threats.

Primary knowledge voids even have a compounding effect on the creation of additional knowledge voids. For example, Congress might not be sufficiently cognizant of the significance (to the CRS policymaking process) of amassing and disseminating knowledge of foreign CRS systems, laws, policies, marketing strategies, technical capabilities, and business practices. As a result, Congress is not inclined to appropriate adequate amounts of money to implement programs for acquiring, analyzing, disseminating this type of knowledge to key decisionmakers in the US CRS policy and regulatory community, particularly when faced with other competing legislative and budgetary pressures. This type of knowledge void (caused by disinterest in CRS) creates a larger knowledge void (i.e., lack of adequate information and knowledge on international CRS issues) and thus contributes to the social construction of macro knowledge voids.

While NOAA has funded such studies in the past, such knowledge has a hard time reaching a wider audience of individuals or groups interested in CRS policies or enabling the general public to become more aware of and interested in CRS issues. To learn about such studies, one has to consult NOAA websites where these sporadic studies are posted. Furthermore, CRS studies need to be regularly updated and effectively communicated to the full spectrum of U.S. CRS stakeholders and industry observers. By not following through with these actions, Congress and the administration (e.g., NOAA, etc.) are unintentionally creating or socially constructing knowledge gaps on the very important and socially beneficial technology of CRS. Such inaction constitutes a socio-political construction of knowledge voids. Cognizant of such problems, recommendations advanced by this dissertation in the following section (i.e., on filling knowledge voids) should help eliminate these socially constructed knowledge gaps and promote the construction of facts, information, and insights on U.S. CRS technology, applications, and policies that truly promote a viable U.S. CRS industry.

Conclusion

This chapter described and analyzed the various actors in the CRS arena, their often conflictive yet occasionally cooperative and collaborative relationships with each other, and the complex systems of CRS satellites and related political dynamics that affect the perceptions and decisions of these actors. Most if not all actors appear to acknowledge the importance and utility of spacebased earth observation by commercial satellite operators. Nonetheless, the dual-use nature of CRS imagery causes these stakeholders to take various, often divisive, stands on how the technology should be developed, operated, and ultimately controlled.

In the private/commercial sector, CRS firms such as DigitalGlobe, Orbimage (GeoEye), and the former Space Imaging, struggled to get a foothold in the domestic and international CRS marketplace, due to unstable policies and obscure regulations governing their business activities. Yet, indecisive government officials were not the only ones to blame for these problems. Industry officials themselves were somewhat unfamiliar if not uncomfortable with the interworkings of USG bureaucratic politics, as well as managing and running their own businesses, since many top management officials in the nascent U.S. CRS field came into their new positions as former Cold War-era technologists and/or officials in the space industry.

Relationships between industry and the legislative branch of the USG have been fairly amicable and productive, resulting in the passage of the Land Remote Sensing Policy Act of 1992, which served as a renewed springboard for propelling the U.S. CRS industry onto a path toward developing, launching, and operating CRS satellite systems. The Act served as a basis from which all ensuing USG policies and regulations on U.S. CRS were formed. Congress even came to bat for industry when it chastised the executive branch in its 1994 hearing concerning bureaucratic delays in licensing new U.S. CRS firms. Yet, knowledge gaps and unfamiliarity with CRS technology and the challenges faced by the U.S. CRS industry (due to a burdensome policy and regulatory environment) has often kept lawmakers from figuring out how to get the administration's full cooperation in the matter (i.e., reach stable and business-friendly policies and regulations). Such knowledge voids also contributed to the inability of the executive branch (particularly NOAA) to develop final CRS rules for over a decade following the passage of the Policy Act. Yet, this lengthy delay is not surprising, given the complex environment within which CRS policies and regulations need to be formulated and executed, as seen in the foregoing study of the vast CRS-related bureaucracy and its relationships with itself and with the CRS industry. In the following and final chapter (Chapter 4), we will see how macro (structural) knowledge voids still plague the CRS industry, and recommendations to rectify that situation will be offered.

Notes

1. Donald MacKenzie, *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance* (Cambridge, MA: The MIT Press, 1990), 9.

2. MacKenzie, "Missile Accuracy: A Case Study in the Social Processes of Technological Change," in Weibe E. Bijker, Thomas P. Hughes, and Trevor Pinch, *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (Cambridge, MA: The MIT Press), 195.

3. Ibid.

4. MacKenzie, *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance*, 2.

5. Ibid, 3.

6. Ibid, 5.

7. NASA's Earth Observing System (EOS) consists of several environmental satellites that monitor the atmosphere (Aura), oceans (Aqua), and land (Terra) See NASA website on these systems at: http://www.spacetoday.org/Satellites/TerraAqua/TerraAquaAura.html, accessed May 19, 2007.

8. See Adele Clark, "A Social Worlds Adventure," in Susan Cozzens and Thomas Gieryn, eds., *Theories of Science in Society* (Bloomington, IN: Indiana University Press, 1990), 15-42; Joan Fujimura, "Constructing Do-able Problems in Cancer Research: Articulating Alignment," *Social Studies of Science*, Vol. 17 (1987), 257-293; and Susan Leigh Star and James R. Griesemer, "Institutional Ecology, 'Translations,' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-1939," in Mario Biagioli, ed., *The Science Studies Reader* (NY: Routledge, 1999), 503-524.

9. Star and Griesemer, 505.

10. Ibid, 506.

11. Ibid, 510.

12. Ibid.

13. Joe Dodd, comments cited by Ben Iannotta, "Setting the rules for remote sensing," *Aerospace America*, Vol. 37, No. 4 (April 1999), 35.

14. R. Winn, Hardin, "Remote sensing satellite market pits industry against U.S. policy," *OE Reports*, No. 185 (May 1999), 2; http://www.spie.org/web/oer/may/may99/home.html, accessed February 6, 2006. Ironically, the EO Reports article again demonstrated how complicated CRS issues tend to be and how knowledge vacuums are created and propagated. For example, the

aforementioned article restated the myth of 1-meter constraints in PDD-23: by stating "This position [support for industry] was reaffirmed and focused by President Clinton's 1994 presidential 'decision directive" that increased the maximum resolution of commercial satellites to 1-m" (Hardin, 3) As demonstrated in Chapter 2 of this dissertation, the only publicly available document on PDD-23 was its fact sheet and nothing in that document said anything about a 1-meter resolution limit. In fact, the *EO report* even went further by stating that the so-called resolution limit "has since been done away with completely" (Ibid) yet no evidence or source was offered to support that assertion. By May 1999 (year of the cited *EO report*), there were no licenses approved for systems that were in the submeter (< 1-meter GSD) range.

15. Kevin M. O'Connell, et. al, *U.S. Commercial Remote Sensing Satellite Industry: An Analysis of Risks* (Santa Monica, CA: RAND, 2001), 100-102.

16. See John C. Baker, Kevin M. O'Connell and Ray A. Williamson, eds., *Commercial Observation Satellites: At the Leading Edge of Global Transparency* (Santa Monica, CA: RAND and Bethesda, MD: American Society for Photogrammetry and Remote Sensing, 2001).

17. Kevin M. O'Connell, et. al., 100.

18. Space Imaging, "Space Imaging and Kodak Announce Delivery of Camera Payload Component for IKONOS 1 Satellite System," August 12, 1997; http://www.spaceimaging.com/newsroom/1997_kodak.htm, accessed April 27, 2006.

19. Lawrence W. Fritz, "The Era of Commercial Earth Observation Satellites," *Photogrammetric Engineering and Remote Sensing*, Vol. 62, No. 1 (January 1996), 41.

20. Gerald M. Steinberg, "Commercial Observation Satellites in the middle East and the Persian Gulf," in Baker, O'Connell and Williamson, 238.

21. Kevin O'Connell and Greg Hilgenberg, "U.S. Remote Sensing Programs and Policies," in Baker, O'Connell and Williamson, 151.

22. Mary Motta, "Space Imaging President Moves to Lockheed;" http://ww.space.com/businesstechnology/business/imaging_breaking_000508.html, accessed April 27, 2006.

23. O'Connell, et. al., xiii.

24. DigitalGlobe, "History [of DigitalGlobe];" http://www.digitalglobe.com/about/history.shtml, accessed March 26, 2006.

25. Ibid

26. Fritz, 40.

27. _____, "QuickBird 1 Kosmos Launch Fails," *SPACEandTECH Digest*

(November 21, 2000); http://www.spaceandtech.com/digest/flash-articles/flash2000-087.shtml, accessed May 30, 2007.

28. Roger Fillion, "Shakeout: Too many companies for too few deals jolt satellite-imaging industry," *Rocky Mountain News* (August 8, 2005); http://www.globalsecurity.org/org/news/2005/050808-satellite-imagery.htm, accessed March 26, 2006.

29. Edward Jurkevics, quoted in Fillion, "Orbit of change for satellite firms. Pared-down industry gets set to launch new-ear technology," *Rocky Mountain News*, January 9, 2006; http://www.rockymountainnews.com/drmn/tech/article/0,2777,DRMN_23910_4373447,00.html, accessed March 26, 2006.

30. Fillion, "Shakeout: Too many companies for too few deals jolt satellite-imaging industry."

31. Fillion, "Orbit of change for satellite firms. Pared-down industry gets set to launch new-ear technology," *Rocky Mountain News* (January 9, 2006); http://www.rockymountainnews.com/drmn/tech/article/0,2777,DRMN_23910_4373447,00.html, accessed May 30, 2007.

32. Ibid.

33. Novariant, Inc., "Novariant Names Herb Satterlee New CEO, Seasoned leadership in agriculture and high-tech industries" (press release), February 14, 2006; http://www.novariant.com/news/pdfs/Herb%20satterlee%20Novariant%20CEO.pdf, accessed July 21, 2006.

34. Fritz, 41.

35. Jason Bates, "Orbimage Reaches Deal to Emerge From Bankruptcy," *Space News*, February 3, 2003; http://www.space.com/spacenews/archive03/orbimagearch_020303.html, accessed March 26, 2006.

36. _____, "ORBIMAGE Completes Acquisition of Space Imaging, Changes Brand Name to GeoEye;" http://www.orbimage-acquisition.com/news/geoEye.htm**,** accessed February 26, 2006.

37. Ibid.

38. Technica, Inc., "News From Technica;" http://www.technicainc.com/, accessed March 13, 2006.

39. Zoominfo.com; http://www.zoominfo.com/Search/Personal.Detail.aspx?PersonalID=17593658&QueryID=cd533eec-d779-443d-9fdf-f2870a645f96, accessed December 8, 2007.

40. Examples of NOAA-sponsored studies are the 2001 RAND Study (see O'Connell, et. al.); work done by William E. Stoney, "ASPRS Guide to Land Imaging Satellites," September 7, 2006; http://www.asprs.org/news/satellites/ASPRS_DATABASE_090707.pdf, accessed September 15, 2007; and a report by Global Marketing Insights, Inc., "Survey and Analysis of Remote Sensing Market, Aerial and Spaceborne, September 2005; http://www.licensing.noaa.gov/Survey/Analysis,pdf, accessed September 9, 2007.

41. George Tahu, John Baker, and Kevin O'Connell, "Expanding global access to civilian and commercial remote sensing data: implications and policy issues," *Space Policy*, Vol. 14, No. 3 (August 1998), 187.

42. Richard G. Johnson, "Supporting the Dayton Peace Talks," in Baker, O'Connell and Williamson, 298-299.

43. John Gates and John Weikel, "Imagery and Mapping Support to the Ecuador-Peru Peace Process," in Baker, O'Connell and Williamson, 319-323.

44. Steinberg, 238.

45. Dan Glickman, comments in U.S. House of Representatives; Committee on Science, Space, and Technology and Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 11.

46. Nick Smith, statement in U.S. House of Representatives; Committee on Science, Space, and Technology and Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 78.

47. Dana Rohrabacher, comments in U.S. House of Representatives, Subcommittee on Space and Aeronautics, Committee on Science, *Hearings on the Commercial Space Act of 1997*, Part I: Commercial Remote Sensing, (May 21, 1997), 3; http://commdocs.house.gov/committees/science/hsy141160.000/hsy141160_0.htm, accessed September 9, 2005.

48. Williamson, "Remote Sensing Policy and the Development of Commercial Remote Sensing," in Baker, O'Connell, and Williamson, 39.

49. See footnote 2 in Charles Mondello, George F. Hepner, and Ray A. Williamson, 10-Year Industry Forecast, phase I-III – Study Documentation, Bethesda, MD: ASPRS, January 2004, 17. The nomenclature error is probably derived from the fact that ERTS-1 (Landsat-1) was an R&D satellite operated by NASA.

50. _____, "The OTA Legacy; http://www.wws.princeton.edu/ota/, accessed April 22, 2006.

51. Rohrabacher, 3.

52. Robert E. Cramer, comments in U.S. House of Representatives, Subcommittee on Space and Aeronautics, Committee on Science, *Hearings on the Commercial Space Act of 1997*, 4.

53. Jeffrey K. Harris, statement in U.S. House of Representatives, Subcommittee on Space and Aeronautics, Committee on Science, *Hearings on the Commercial Space Act of 1997*, 10.

54. Ibid, 38.

55. Rohrabacher, 12.

56. Ibid, 28.

57. Rohrabacher, statement in U.S. House of Representatives, Subcommittee on Space and Aeronautics, Committee on Science, Hearings on the Commercial Space Act of 1997, Part III, June 4, 1997, 89.

58. Cheryl Roby, statement in U.S. House of Representatives, Subcommittee on Space and Aeronautics, Committee on Science, *Hearings on the Commercial Space Act of 1997*, 104.

59. The full title of the treaty is the "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies."

60. Ram Jakhu, "International Law Governing the Acquisition and Dissemination of Satellite Imagery, in James F. Keeley and Rob Huebert, ed. *Commercial Satellite Imagery and United Nations Peacekeeping: A View From Above*, Burlington, VT: Ashgate Publishing Company, 2004, 15.

61. Sheila Jackson Lee, comments in U.S. House of Representatives, Subcommittee on Space and Aeronautics, Committee on Science, Hearings on the Commercial Space Act of 1997, Part III, 114.

62. Richard Davis, "The Foreign Policymaking Role of Congress in the 1990s: Remote Sensing Technology and the Future of Congressional Power," *Congress and the Presidency: A Journal of Capital Studies*, Vol. 19, No. 2 (Autumn 1992), 176.

63. White House, National Science and Technology Council, *Fact Sheet: National Space Policy*, September 19, 1996; http://www.ostp.gov/NSTC/html/fs/fs-5.html, accessed September 25, 2005. Also see Linda L. Holler and Melvin S. Sakazaki, "Commercial Space and United States National Security" (paper prepared for the Commission to Assess United States National Security Space Management and Organization), no date; Commission Report dated January 11, 2001; http://www.fas.org/spp/eprint/article06.html#rft50, accessed February 4, 2006.

64. Ibid.

65. Tom Cecere, "Commercial Remote Sensing Space Policy (CRSSP) and Opportunities for Collaboration" (presentation to the EPA 2005 Science Forum: Collaborative Science for

Environmental Solutions held in Washington, DC on May 16-18, 2003); http://www.epa.gov/ord/scienceforum/2005/pdfs/presentations/7-Cecere_Tom%20revised.pdf, accessed April 22, 2006.

66. Ibid, 4.

67. Ibid.

68. U.S. House of Representatives, Committee on Science, Subcommittee on Space and Aeronautics, Hearings on the Commercial Space Act of 2003 (H.R. 3245), November 5, 2003; http://www.louisdb.org/ch/viewphp?documentURL=hearnings/108/house/House-hearing-108-90164.html?v=1&q=commercial+space+act&published-Max=2007-09-30&max-results=10&cat=ch&pubminmonth=&pubmaxmonth=90-30&pubminyear=&pubmaxyear=2007, accessed September 9, 2007.

69. Office of Space Commercialization, NOAA, Department of Commerce, FAQ webpage; http://www.nesdis.noaa.gov/space/about/faq.html, accessed April 22, 2006.

70. Office of Space Commercialization, "Satellite Imaging," http://www.nesdis.noaa.gov/space/imaging/, accessed April 22, 2006.

71. National Oceanic and Atmospheric Administration, "Ed Morris Named Office of Space Commercialization Director" (press release 2006-R300), February 1, 2006; http://www.publicaffairs.noaa.gov/releases2006/feb06/noaa06-r300.html, accessed April 22, 2006.

72. Office of Space Commercialization, "GIS Capabilities for Civil Government Organizations: Building a Bridge to a Safe, Secure, and Prosperous Future (Speaker Biographies); http://www.nesdis.noaa.gov/space/library/workshops/2006-10-19/biographies.html, accessed May 30, 2007.

73. National Research Council, Space Studies Board, *Toward New Partnerships In Remote Sensing: Government, the Private Sector, and Earth Science Research* (Washington, DC: The National Academies Press) 2002, 13.

74. Conversation with Gabrynowicz at the September 13, 2005 ACCRESS meeting. Also see Pamela E. Mack, *Viewing the Earth: The Social Construction of the Landsat Satellite System* (Cambridge, MA: The MIT Press), 1990. Dr. Mack received her doctorate from the University of Pennsylvania, was highly influenced by Thomas Hughes's theory of large technological systems, has taught at Virginia Polytechnic Institute and State University (Virginia Tech), and is currently an associate professor of history at Clemson University. Virginia Tech provided part of the funding for her research on her dissertation-turned book on the Landsat program.

75. Personal notes taken by Ken Thompson during the "NOAA Workshop on Commercial Remote Sensing Licensing, Washington, DC, September 13, 2005.

76. Ibid.

77. Kay Weston, "NOAA Issues for Discussion" (briefing) in Advisory Committee for Commercial Remote Sensing (ACCRES), National Oceanic and Atmospheric Administration (NOAA), Open Session Meeting Summary [7th Meeting], September 13, 2005; http://www.accres.noaa.gov/7thMeeting09-13-05.pdf, accessed September 14, 2007.

78. O'Connell, et. al., xi.

79. Ibid.

80. Ibid, 75-76.

81. For insights into formation of paradigms, see Thomas Kuhn, *The Structure of Scientific Revolutions*, 2nd edition, (Chicago: The University of Chicago Press, 1970). For discussions of dominant social groups in technological frames and the negotiation process of technological development, see Weibe E. Bijker, "The Social Construction of Bakelite: Toward a Theory of Invention," in Bijker, Hughes, and Pinch, 159-187.

82. O'Connell, et. al, 83.

83. Ibid, 67.

84. National Aeronautics and Space Administration, National Oceanic and Atmospheric Administration, and U.S. Geological Survey, "Management Plan for the Landsat Program," August 10, 1994; http://geo.arc.nasa.gov/sge/landsat/mgmtplan.html, accessed May 24, 2007.

85. Department of State; http://www.state.gov/t/np/rls/other/32887.htm#ecnp0, accessed January 29, 2006 (since discontinued).

86. Department of State; http://www.state.gov/t/ac/16188.htm, accessed January 29, 2006 (since discontinued).

87. David B. Sandalow, "Remote Sensing and Foreign Policy" (remarks delivered at the Symposium on "Viewing the Earth: The Role of Satellite Earth Observations and Global Monitoring in International Affairs)," Washington, DC: The George Washington University, June 6, 2000, 6; http://www.gwu.edu/~spi/vtespeech.html, accessed February 11, 2006.

88. Baker and Johnson, "Security Implications of Commercial Satellite Imagery," in Baker, O'Connell, and Williamson, 104.

89. Tahu, "Russian Remote Sensing Programs and Policies,: in Baker, O'Connell, and Williamson, 166 and 173.

90. Bill Gertz, "Crowding In on The High Ground," *Air Force Magazine Online*, Vol. 80, No. 4 (April 1997), 1; https://www.afa.org/magazine/April1997/0497crowding.asp, accessed

February 5, 2006.

91. Ibid, 2-3.

92. Ibid, 4.

93. For a summary of the policy, see The White House, National Science and Technology Council, Fact Sheet: National Space Policy; http://www.ostp.gov/NSTC/html/fs/fs-5.html, accessed July 16, 2006.

94. Kerry Gildea, "Clapper: NIMA Unlikely to Enter Exclusive Access Deals for Commercial Industry," *Defense Daily Network* (June 6, 2002), quoting James Clapper; http://www.defensedaily.com/cgi/catalog/sample?C4I, accessed February 5, 2006)

95. James Bilbray, comments in U.S. House of Representatives; Committee on Science, Space, and Technology and Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 72

96. Robert Gallucci, statement in U.S. House of Representatives; Committee on Science, Space, and Technology and Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 73.

97. John R. Jensen, statement in U.S. Senate, Committee on Commerce, Science, and Transportation, Subcommittee on Science, Technology, and Space, S. 2297, The Land Remote Sensing Policy Act of 1992," (hearing), Washington, DC: U.S. Government Printing Office, 55.

98. Ibid, 58.

99. Dana Rohrabacher, statement in U.S. Congress, Committee on Science, Space, and Technology and the Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 74.

100. For technical parameters of Landsat 4 and 5 scanning devices see _____, "Landsat-4/-5," eoPortal Directory; http://directory.eoportal.org/pres_Landsat4and5.html, accessed June 2, 2007. For specifications of the SPOT 2 scanner system, see _____, "SPOT-1/-2 (System Pour l'Observation de la Terra)," eoPortal Directory; http://directory.eoportal.org/pres_SPOT12SystmePourlObservationdelaTerre.html, accessed June 2, 2007.

101. Gildea, "Lawmakers Put Pressure on DoD to Devise Commercial Imagery Strategy," *Defense Daily Network*, June 6, 2002, click on 3rd bullet (article); http://www.defensedaily.com/cgi/catalog/sample?C4I#A3, accessed February 5, 2006.

102. Ibid.

103. Ibid, 6.

104. Roby, "Statement for the Record of Ms. Cheryl, Principle Director for Intelligence (Intelligence and Security), Office of the Assistant Secretary of Defense)," (Hearings on H.R. 1702), Washington: U.S. House of Representatives; Subcommittee on Space and Aeronautics; Committee on Science, June 4, 1997; http://www.house.gov/science/roby_5-4.html, accessed February 8, 2006.

105. Ibid.

106. Ibid.

107. Jeffrey S. Galway, "Defense Remote Sensing Working Group (DRSWG)" (briefing), Washington: NOAA Workshop on Commercial Remote Sensing Licensing, Sept 14, 2005, 1.

108. Ibid, 2.

109. Frank Sietzen, Jr., "A ClearView of NIMA's Commercial Imagery Use," *Geospatial Solutions*, (March 1, 2002); http://www.geospatial-online.com/geospatialsolutions/article/articleDetail.jsp?id=48147, accessed April 23, 2006.

110. Ibid (quoting Bill Weed, Chief of Commercial Imagery Management Staff, NIMA).

111. Ibid.

112. Dan Caterinicchia, "NIMA seeks 'Clearview' of world," January 17, 2003; http://www.govhealthit.com/article78527, accessed July 15, 2006.

113. ______, "DigitalGlobe Awarded $500 Million NextView Contract from NIMA," *Space Daily*, October 1, 2003; http://www.spacedaily.com/news/eo-03zzza.html, accessed July 15, 2006.

114. Sietzen.

115. Phone conversation with Chuck Herring on October 4, 2004, the same day that Spaceship One (a private rocket-plane) the won the X-Prize contest for exceeding an altitude of 328,000 feet above the earth. Herring commented that it would be ideal if that feat would promote a cheaper launch system for CRS satellites.

116. David Bartlett, letter dated February 8, 1994 to Congressman George E. Brown, Jr. and Dan Glickman, U.S. Congress, Committee on Science, Space, and Technology and the Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 133-135.

117. Warren Ferster, comments in Judith Carrodeguas and Dan Stillman, eds., "Commercial Satellite Remote Sensing Symposium: Improving the International Business Environment"

(Proceedings), Washington: Institute for Global Environmental Strategies (IGES), 35; http://www.strategies.org/symposium/SymposProcedings.pdf, accessed February 12, 2006.

118. Charles Devarics, “Private eyes: Commercial satellite imagery in demand for intelligence and disaster recover,” *C4ISR* (November 28, 2005); http://www.isrjournal.com/story.php?F=1130593, accessed April 23, 2006.

119. Scottie Barnes, “Open Access,” *Geospatial Solutions*, Vol. 14, No. 10 (October 1, 2004), 10.

120. Ibid.

121. Williamson, 47.

122. Jason Bates, “Plan Would Put the USGS In Charge of Buying Commercial Imagery,” *Space News* (January 5, 2004); http://www.space.com/spacenews/archive03/usgsarch_122303.html, accessed February 14, 2006.

123. Ibid.

124. Ibid.

125. _____, “Space Imaging Wins USGS Contract for Commercial Satellite Imagery, *redOrbit News*; http://www.redorbit.com/modules/news/tools.php?tool=print&id=62653, accessed February 14, 2005.

126. Ibid.

127. ______, “USGS Awards Contracts for Commercial Satellite Imagery,” *Directions Magazine* (June 7, 2004); http://www.directionsmedia.net/newsletters.archive/index.php?ID=395, accessed February 14, 2006.

128. U.S. Geological Survey, “Commercial Remote Sensing Space Policy (CRSSP), Center for Earth Resources Observation and Science (EROS); http://crsp.usgs.gov, accessed September 4, 2005.

129. U.S. Geological Survey, “Policy History;” http://crsp.usgs.gov/background.php, accessed on Sep 4, 2005. Perhaps reflective of knowledge gaps or just plain mistakes or typographical errors, the CRSSP website lists as one of its reference documents (i.e., applicable laws) for the history of CRS policy the Commercial Space Act of 1998 (PL 105-303, enacted October 28, 1992). Actually, the law was enacted on October 28, 1998. The error or confusion could have been with the preceding document citation on the Land Remote Sensing Policy Act of 1992 (enacted October 28, 1992), or with the coincidence of the months and dates (that the Acts were signed into law) being the same.

130. _____, “Remote Sensing Interagency Working Group” (slide briefing), NOAA Workshop on Commercial Remote Sensing Licensing, 2.

131. Ibid, 1.

132. Ibid, 2.

133. Ibid.

134. For NGA, the term “geospatial” is not hyphenated. The hyphen actually connects “geospatial” with “intelligence” to make a three-letter acronym, instead of four (which would have been NGIA), ostensibly to keep the agency part of the three-letter club of IC members. More than likely, the term “Imagery” could have been mistakenly derived from the former name of NGA – National Imagery and Mapping Agency (NGIA). It is also very possible that the erroneous term “Office” ascribed to NGA was confused with the term “Office” in the National Reconnaissance Office (NRO), an organization that builds and operates military reconnaissance satellites. Another possibility is that the confused agency designation might have come from an older name for NIMA, the Central Imagery Office (which was established in 1992 but was later replaced by NIMA in 1996).

135. Jeffrey S. Galway, “Defense Remote Sensing Working Group (DRSWG” (briefing), Washington, DC: NOAA Workshop on Commercial Remote Sensing Licensing, September 14, 2005, 1.

136. Ibid.

137. Ibid.

138. Gabrynowicz, videotaped lectures of a course entitled Space Studies 575: Remote Sensing Law and Policy, Grand Forks, ND: University of North Dakota (UND Aerospace), Spring 2000.

139. O’Connell, et. al, 90.

140. See O’Connell, et. al.

141. Ibid, 65-67.

142. Glickman, comments in U.S House of Representatives, Committee on Science, Space, and Technology and House Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post Cold War Era*, 11.

143. George Brown, comments in U.S House of Representatives, Committee on Science, Space, and Technology and House Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post Cold War Era*, 1.

144. R. James Woolsey, statement in U.S House of Representatives, Committee on Science, Space, and Technology and House Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post Cold War Era*, 22.

145. Ibid, 24.

146. Brown, 30-31.

147. Robert S. Walker, comments in U.S House of Representatives, Committee on Science, Space, and Technology and House Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post Cold War Era*, 35.

148. O'Connell, et. al, 70.

149. D. James Baker, statement in U.S. House of Representatives; Committee on Science, Space, and Technology and Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 38.

150. Norman D. Dicks, comments in U.S. House of Representatives; Committee on Science, Space, and Technology and Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 38.

151. 15 United States Code 82, Land Remote Sensing Policy, Subchapter II, Licensing of Private Remote Sensing Space Systems, Sec. 5621, General Licensing Authority. Available at http://geo.arc.nasa.gov/sge/landsat/15USCch82.html, accessed April 23, 2006.

152. Ibid.

153. Gallucci, 70.

154. Scott Pace, statement in U.S. House of Representatives; Committee on Science, Space, and Technology and Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 29.

155. Glickman, 71.

156. White House, Office of the Press Secretary, Foreign Access to Remote Sensing Space Capabilities, Statement and Fact Sheet [PDD-23], Washington, DC, March 10, 1994; http://www.fas.org/irp/offDOCs/pdd23-2.htm, accessed October 15, 2005.

157. Anna C. Eshoo, comments in U.S. House of Representatives; Committee on Science, Space, and Technology and Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 80.

158. Ibid.

159. _____, "Foreign competition may be the only way to lift U.S. regs," *EO Reports,* No. 185 (May 1999); http://www.spie.org/Web/oer/may/may99/cover1.html, accessed February 9, 2006.

160. Steinberg, 237-238.

161. Theresa Hitchens, "Commercial Imagery: Benefits and Risks," (speech delivered at a conference entitled "U.S. Space Operations in the International Context), Washington, DC, Center for Defense Information, March 3, 2004; http://www.cdi.org/program/document.cfm?DocumentID=2111&from_page=../index.cf..., accessed April 23, 2006.

162. U.S. Senate, Congressional Record: National Defense Authorization Act for Fiscal Year 1997 (Kyl-Bingaman Amendment), Sec. 1043: Prohibition on Collection and Release of Detailed Satellite Imagery Relating to Israel and Other Countries and Areas, Washington, DC, June 26, 1996.

163. U.S. Senate, Congressional Record: National Defense Authorization Act for Fiscal Year 1997, Amendment No. 4321, "Purpose: Prohibition on Collection and Release of Detailed Satellite Imagery Relating to Israel and Other Countries and Areas," Washington, DC, June 26, 1996.

164. See Office of Technology Assessment, *Civilian Space Policy and Applications* (Washington, DC: U.S. Government Printing Office, June 1982). Also see Office of Technology Assessment, *Remote Sensing and the Private Sector: Issues for Discussion – A Technical Memorandum*, *OTA-TM-SSC-20* (Washington, DC: U.S. Government Printing Office, March 1984).

165. Daniel S. Greenberg, "Bring Back OTA – Congress' Own Think Tank – Legislators need objective scientific advice," *The Scientist* (May 19, 2003); http://www.freerepublic.com/focus/f-news/914740/posts, accessed September 3, 2007. The web version is used instead of the actual article printed in *The Scientists* to capture web postings and comments about the article.

166. Gregory Withee, opening remarks in Judith Carradeguas and Dan Sullivan, eds., *Commercial Remote Sensing Symposium Proceedings* (May 13-15, 2003), Washington, DC: Institute of Global Environmental Strategies, 2004, 22.

167. John Curlander, comments during a symposium entitled "Commercial Satellite Remote Sensing Symposium: Improving the International Business Environment Proceedings," Washington, DC: NOAA, NASA, USGS, May 15, 2003, 41-42; http://www.licensing.noaa.gov/SymposProceed-Mar9.pdf, accessed April 23, 2006.

168. Steinberg, 236-237.

169. White House, Office of the Press Secretary, Foreign Access to Remote Sensing Space Capabilities, Statement and Fact Sheet [PDD-23].

170. Walter Scott, statement in U.S. House of Representatives; Committee on Science, Space, and Technology and Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 99.

171. Ibid, 139. The picture of the image was provided to the Congressional hearing by Douglas A. Rekenthaler, President of Darnavka International Space Monitoring Association, Woodbine, Maryland; from May 1990 archives.

172. Tahu, 171, 173-174.

173. Leonard S. Spector, "The Not-so-Open Skies," in Krepon, et. al., *Commercial Observation Satellites and International Security*, NY: St. Martins Press 1990, 164.

174. Iannotta, 35.

175. Ibid (quoting Thom Goertel).

176. Marco Caceres, "Focus sharpens for imaging satellite imagery," *Aerospace America*, Vol. 38, No. 9 (September 2000), 16.

177. Davis.

178. David Brannon, statement in U.S. House of Representatives, Subcommittee on Basic Research, "Using Commercial Data Sources in the Earth Science Enterprise," Washington, September 28, 1998; http://www.hq.nasa.gov/congress/brannon9-28.html, accessed April 10, 2006.

179. Pace, statement in U.S. House of Representatives, Subcommittee on Basic Research, "Using Commercial Data Sources in the Earth Science Enterprise," Washington, September 28, 1998; http://www.house.gov/science/pace_09-28.htm, accessed April 10, 2006. ESE was originally called the "Mission to Planet Earth" Program but changed its designation in 1998. Yet, changes in mission titles or programs often escape the accurate knowledge of individuals or organizations dealing with remote sensing applications and issues. A prime example of this type of knowledge gap was identified in April 2006, when Scientific Applications International Corporation (SAIC) touted its experience in the remote sensing and GIS fields, claiming that its experience extended to (among others) "…providing support to Mission to Planet Earth programs" (see SAIC advertisement, *Photogrammetric Engineering and Remote Sensing*, Vol. 72, No. 4 (April 2006), 466. The problem with this claim is that the Mission to Planet Earth program, which was introduced in 1989, was renamed the Earth Science Enterprises (ESE) Program in 1998, nearly 8 years before the date of the advertisement. These types of knowledge gaps manifest a lack of familiarity with or currency in factual information about organizational changes (see Scott Pace, Brant Sponberg and Molly Macauley, *Data Policy Issues and Barriers to Using Commercial Resources for Mission to Planet Earth*, Santa Monica, CA: RAND, iii. Also see O'Connell and Hilgenberg, in Baker, O'Connell, and Williamson, 141. In addition, see Douglas Isbell, "Mission To Planet Earth Enterprise Name Changed to Earth Science [Press] Release: 98-12," Washington, DC: NASA, January 21, 1998; http://www.gsfc.nasa.gov/news-

release/releases/1998/h98-12.htm, accessed April 10, 2006). Although it is possible that the advertisement was a recycled piece originally written prior to 1998, evidence against such would be the fact that the same advertisement accounted for the change in another imagery-/remote sensing-related organization (i.e., NIMA to National geospatial-Intelligence Agency (NGA), which occurred in November 2003. According to the advertisement, SAIC presented itself as a major producer under NGA's Global Geospatial-Intelligence Production Contract. By stating a post-2003 name change for NIMA, it would appear to be illogical to conceive of a possibility that the advertisement pre-dated that name change (supra note 168).

180. O'Connell and Hilgenberg, 158.

181. Brannon.

181. Ibid.

Chapter 4

Analysis and Recommendations

Introduction

Previous chapters introduced and examined the political environment and historical context of U.S. CRS, knowledge voids that contribute to policy conflicts among relevant groups involved in CRS activities, and how U.S. CRS is socially and politically constructed based on interests, goals, relationships, organizational roles, and awareness and comprehension of the complex issues related to U.S. CRS in its domestic and global context. This final chapter examines and critically analyzes the policy perspectives and actions of the USG and the U.S. CRS industry. It also focuses on perception gaps and structural knowledge voids to determine their influence on CRS policymaking and examines the connection between knowledge voids, perception gaps, and CRS-related policy/regulatory decisions. Finally, this chapter offers recommendations for filling knowledge gaps and for crafting more effective CRS policies and regulatory regimes and points to future STS research areas that could benefit CRS or civil earth observation technologies and applications.

Analysis of Government/Industry Perspectives and Actions

To critically analyze the perspectives and actions of government and industry stakeholders involved with U.S. CRS issues, this section is broken down into subsections according to the two major historical periods of CRS (i.e., the privatization period from 1984 to 1992 and the transitional period from 1992 to the present date). Each subsection examines the major legislative, policy, and regulatory milestones set by the USG and the perspectives and actions of the CRS industry based on those actions. This history-based approach enables one to comprehend and analyze successive trends in knowledge or knowledge gaps and policy perceptions concerning the complicated and contentious aspects of CRS and how well U.S. CRS policy and regulatory instruments and decisions accomplish their stated goals. The CRS legislative and policy milestones (documents) consist of the Land Remote Sensing Commercialization Act of 1984, the Land Remote Sensing Policy Act of 1992, Presidential Decision Directive-23, the Commercial Space Act of 1998, and the U.S. Commercial Remote Sensing Space Policy of 2003 (see Appendix A through E for each of the legal and policy documents).

Privatization Period (1984-1992)

<u>*Government Perceptions and Actions*</u>

As was discussed in Chapter 1, the USG began contemplating (in the early 1980s) that the time had come to privatize or commercialize the Landsat system, thus gradually saving scarce taxpayer dollars earmarked for other programs and national priorities. The first major milestone in the USG's attempts to commercialize U.S. remote sensing satellite systems was the Land

Remote Sensing Commercialization Act of 1984. This USG action has been extensively studied and analyzed by numerous scholars and observers of U.S. CRS. The most in-depth analysis of the Commercialization Act was conducted by Donald Lauer in his 1990 dissertation assessing USG policies for the Landsat program.[1] According to Lauer and others who have studied this formative period of U.S. CRS, the 1984 Commercialization Act ended up being a failure and was eventually replaced by the 1992 Land Remote Sensing Policy Act. As mentioned in preceding chapters, there were several causes for this failure, among them being knowledge gaps concerning the economic viability of a CRS venture in the 1980s, vacillating financial and budgetary support for the privatized Landsat system, lack of a strong proponent within the USG for a robust CRS program, and, perhaps most importantly, lack of a supporting information infrastructure and effective CRS data marketing policies.[2]

Many of these factors can probably be linked to knowledge gaps or unwillingness or inability to act on more complete knowledge that was actually available during this formative period of U.S. CRS. The bottom line is that the Landsat system should have never been privatized back in 1984 when the space imagery data market was unable to support such a bold experiment and when the USG was not sufficiently committed to massively subsidizing the privatized Landsat program. Yet, the problem at that time was USG efforts to constrain federal spending on programs that it deemed were not as essential as other domestic programs and Cold War defense projects in the mid- to late 1980s. Although attempts were made to fill knowledge gaps on the economic viability of a privately operated Landsat program in the 1980s and beyond, such efforts (consisting of several feasibility studies) were largely ignored or perhaps misunderstood by the USG, resulting in the near demise of the Landsat program and emergency bailouts for the Landsat contractor, EOSAT. Faced with making a choice between total and continued government funding of the Landsat program and privatizing it to cut government spending, the Reagan administration and Congress intentionally chose to overlook knowledge (available in at least six studies warning against accelerated commercialization of Landsat) that would have made their policy/legislative actions inadvisable. The lesson of this historical event is that policymakers can intentionally create their own convenient knowledge voids concerning policy issues if specific advice and/or knowledge offered by experts would force them to make decisions that conflict with their interests and preconceived notions.

In the late 1980s, USG perceptions increasingly focused on the national security implications of future CRS systems capable of high-resolution imaging. Yet, some in DOD and the IC realized that such thinking and perceptions had to change due to competition from French, Russian, and Indian satellites. For instance, at a 1989 symposium on foreign policy and remote sensing held at the University of Kentucky, one administration official, Roland Inlow (former IC expert on imagery exploitation) suggested that it “may be time to rethink [U.S. CRS] policy.”[3] Still, Inlow viewed a proposed medium- to high-resolution CRS satellite for journalistic applications, called “mediasat,” as potentially complicating national security objectives and called for a rational yet cautious approach to developing such a system and concomitant policies and regulations.[4] Reflecting the ambivalent views of many national security officials at the time, Inlow opined that “the current policy environment is not conducive to aggressive or innovative long-range planning and action by the private sector because it presents too many restrictions and uncertainties. The present policies work very well for national security interests but inhibit significant initiatives by the U.S. private sector.”[5] Echoing Inlow’s policy perspectives, retired

Major General Jack Thomas suggested that U.S. defense officials would be very wary of future CRS systems that provided resolution capabilities that exceeded other satellite systems at the time [which would have been French imagery at 10 meters and Russian imagery at 5 meters] and that, if such a CRS system were authorized, it would need to be subjected to occasional operational restrictions [e.g., shutter control].[6]

The U.S. Congress did not generally share such cautionary perspectives by the executive branch. For example, Congressman George Brown, Jr., chief architect of the 1992 Policy Act, was a staunch supporter of CRS and of returning the Landsat program to government control. Brown viewed the Reagan administration's attempts to make the Landsat system a viable commercial venture as being seriously flawed. Sharing his views on the subject and those of his fellow members of Congress, Brown stated at the aforementioned 1989 symposium that the Reagan administration had made a "series of blunders over the past five years [i.e., since the Commercialization Act of 1984] in trying to privatize a valuable national program–Landsat–and as a result has jeopardized a real jewel of our space effort."[7] Brown continued: "Yet remote sensing is a technology that the U.S. pioneered, and it is a component of our space program that has provided substantial international prestige over the years. I will tell you quite bluntly that this [USG failure to dependably fund Landsat] is the sort of situation that burns the britches of Members of Congress."[8] According to Brown, "What is fundamentally needed at this juncture is a complete appraisal of the nation's interests, intentions, and goals in the area of remote sensing for the next 10 to 15 years."[9]

The lessons learned during this policy fiasco period can contribute to the understanding and realization that remote sensing is not just a technological or data marketing issue that can be solved by transferring U.S. satellite imaging systems to commercial vendors and promising to support their operations with gradually decreasing government subsidies. It is also a socio-political issue that STS studies can effectively inform. Not only should the data marketing feasibility studies have focused on the technical and economic aspects of a "commercialized" Landsat program (which they did), they should also have examined and elucidated the multiple interests, missions, and interrelationships of the players involved in the Landsat program and its implementing policies and the consequences of premature commercialization of such a valuable national asset as the Landsat system.

Successful CRS policies are not just those that consider the economic and technological ramifications of earth observations systems; they should also consider the organizational roles, missions, interests, and interrelationships of various USG agencies and industry actors that have a stake in U.S. CRS activities. That involves a deepening and extension of extant knowledge of the myriad dimensions of CRS and then effectively acting on such enhanced knowledge to implement effective U.S. CRS policy and regulatory measures. Ultimately, the CRS policy failure of the 1980s led to USG actions (i.e., Congressional hearings) to save the Landsat program by returning it to full government control and passing another piece of legislation to promote a true CRS industry in the U.S. (i.e., the 1992 Land Remote Sensing Policy Act).

Industry Perspectives and Actions

Other than EOSAT, the U.S. CRS industry was not a significant player in the process of crafting policies to support a CRS industry base in the U.S. during the privatization period. There was only one civil land imaging satellite program to be operated at the time (i.e., Landsat-4 and -5) and EOSAT was the only private entity involved in that privatization project. Those who actively supported industry's viewpoints perceived that CRS was a valuable and useful technology and needed to be aggressively supported through realistic public policies. The actions of these proponents ranged from open clashes with the government (in the case of EOSAT as will be discussed below) to participating in forums and discussions on how best to stimulate greater interest in developing CRS satellite systems. By the late 1980s, supporters of future CRS satellites voiced their opinions on the prospects of developing a medium- to high-resolution satellite imaging technology. At the time, there was a growing interest in CRS, such as a concept for a mediasat or newsgathering satellite system. Allied with industry, proponents of such a system saw it as beneficial for reporting on foreign policy issues and as a counterweight to official government information.

Media representatives, academics, and other CRS advocates generally viewed the utility of a future CRS system as augmenting official information on foreign policy issues and actually benefiting national security by providing transparency to international affairs. During the 1989 symposium, EOSAT representative Peter Norris pointed out the utility of earth observation imagery in supplementing news coverage of the 1986 Chernobyl accident and other disasters such as the 1986 volcanic eruption in Alaska.[10] Echoing Norris's perspectives on CRS, Laurent Scharff, a Washington, D.C. lawyer with Reed, Smith, Shaw and McClay, clearly sided with industry and the media and called for a new policy regime to promote the CRS industry. Scharff suggested that, "In the event that NOAA does not adopt rules needed for this space competition [i.e., effective CRS regulations], the Congress should amend the Landsat Act [1984 Commercialization Act] to clarify the national security and commercial imperatives without the one impinging on the other."[11]

In addition, CRS industry supporters increasingly lobbied for Congressional action to pass new legislation that would truly promote a viable CRS industry in the U.S. and make it competitive with future CRS systems operated by foreign nations. The Russian and French advances in this domain lent credence to the claims of proponents of U.S. CRS and propelled the U.S. into a new era of CRS policymaking. Fortunately, the mistakes of the privatization period served as lessons learned in assisting Congress and the administration in crafting and implementing new laws and policies that helped create a better political and economic environment in which future U.S. CRS satellite operators could grow and prosper. The learning curve was gradually being surmounted.

Transitional Period (1992-Present)

<u>Government Perceptions and Actions</u>

After a lengthy period of flawed policy decisions and lack of robust commitment to supporting the grand experiment of commercializing the Landsat system, the USG began in the early 1990s to make progress toward fairly effective yet less than perfect policy regimes to promote U.S. CRS activities. Such progress was made in an environment of conflict and collaboration among key players and stakeholders in U.S. CRS activities. Eventually, the interactions resulted in a gradual increase in cooperation and partnerships between the U.S. CRS industry and its government patrons, customers, and regulators. Key to understanding how this process unfolded is examining and analyzing the views and actions of the USG in meeting two major objectives: 1) fostering growth within the U.S. CRS industry, and 2) ensuring that U.S. national security and foreign policy interests were maintained.

Shortly after passage of the 1992 Policy Act, the USG moved to license several CRS companies such as WorldView Imaging (forerunner of DigitalGlobe), EOSAT, Space Imaging and others. Both Congress and the administration perceived that a strong U.S. CRS industrial base needed to be supported based on their conviction that the U.S. had to regain the technological lead in operating non-military earth observation satellites. Yet, even until the late 1990s, Russia and France remained at the forefront in non-military earth observation systems with their 2-meter and 10-meter satellites, respectively. It was not until 1999 that Space Imaging began offering 1-meter imagery after the successful launch of its Ikononos-2 satellite in September of that year.

Despite the perceived need to recapture the lead in CRS systems, the USG's perspective on CRS was mixed during the early part of the transitional period. For example, the U.S. national security community wanted to limit the capabilities of future U.S. satellite systems to be licensed by NOAA by inserting a shutter control clause in the 1994 PDD-23, which was absent from the 1992 Policy Act. Conversely, the USG used the Policy Act and especially PDD-23 to voice its support for the future U.S. CRS industry. According to the fact sheet on PDD-23, the USG would "support and enhance US industrial competitiveness in the field of remote sensing space capabilities while at the same time protecting US national security and foreign policy interests."[12] Much of the wording of the Policy Act and the public version of PDD-23 (i.e., fact sheet) was vague and, aside from fairly detailed provisions on what was required of future CRS licensees, the document provided little guidance on how the U.S. CRS policy would be implemented or how the U.S. CRS industry would successfully compete with foreign CRS systems. Although this might be an example of an intentional knowledge void, such would be hard to prove. Ostensibly, the policy was broadly written to simply reflect the USG's general goals for CSR and left implementation of the policy to DOC, DOD, DOS, DOI and other USG agencies. In this particular case, the policy was crafted expeditiously due to Congressional pressure. In part, such pressure came from a February 1994 joint hearing of the Committee on Science, Space, and Technology and the House Permanent Select Committee on Intelligence, likely prompting quick issuance of PDD-23 just one month later in April 1994. Furthermore, the non-public version of PDD-23 would have been much more detailed and would have contained more specific implementation language than the White House fact sheet.

Essentially, PDD-23 was not so much a policy promoting industry as it was a policy for regulating it. Very little verbiage in the policy's fact sheet was devoted to the stated goal of the USG to promote the U.S. CRS industry. Most of the 1994 policy dealt with conditions under which future CRS licensees would have to operate, including potential shutter control measures that reflected USG concerns over the impact of high-resolution imagery on national security and international relations. At the time and for several years later, the U.S. CRS industry felt the policy of shutter control would hamper its ability to compete in the global marketplace for remote sensing imagery. The USG's rationale for its shutter control policy was to ensure that it had the means to prevent sensitive imagery from falling into the hands of its adversaries or the adversaries of its allies.

In 1996, the Clinton administration issued its National Space Policy, but much of its language on CRS was also vague and did not specify how a USG policy of promoting CRS would be implemented. Nonetheless, the 1996 policy was another step towards developing a legal/policy framework for fostering a viable U.S. CRS industry some four years after PDD-23. Later in 1998, Congress passed the Commercial Space Act, which changed the wording of the Policy Act on the subject of CRS-related foreign agreements from "any" agreements, to "significant and substantial."[13] This was very favorable to the U.S. CRS industry but still left the definition of "significant" and "substantial" debatable. Although a step in the right direction, the terms 'significant' and 'substantial" are non-specific as to their meaning and applicability. Such undefined terms allowed the USG to maintain as much flexibility as it could to simultaneously promote yet control the CRS industry. It is highly possible that this was another manifestation of an intentional knowledge void, which has also been characterized as "knowledge a***<u>void</u>***ance."[14] Not having substantial knowledge on the types of international agreements required by U.S. CRS firms makes it easy to just conveniently term them as either "any" agreement or "significant and substantial" agreements. In stark contrast to the vagueness of this terminology in USG policy documents, the U.S. CRS industry often expresses its desire for more specificity in the language of CRS laws, policies, and implementing regulations.

During the CRS transitional period, USG policies and regulations for CRS activities gradually evolved toward a more industry-friendly environment for U.S. CRS satellite operators. While several factors account for this policy evolution, increasing awareness and appreciation of the utility of CRS imagery for national defense purposes, lobbying by the CRS industry in various forums, and realization that foreign high-resolution CRS systems were on the horizon likely prompted the USG into refining its CRS policies and regulations to more effectively bolster the U.S. CRS space industry.

By the early 2000s, the USG (i.e., DOC) began instituting procedures and establishing forums that would significantly help bolster the fledgling U.S. CRS industry, chief among them being the creation of a federal advisory committee on CRS. In 2002, NOAA established ACCRES and has used that forum ever since to hold periodic meetings to discuss ways to promote the CRS industry and streamline its CRS regulatory process. It has been one of the paramount success stories in the history of U.S. CRS policymaking by providing a mechanism for fostering collaboration between the CRS industry and USG agencies, with input from other experts and advocates of CRS technology.

The most recent and significant action (milestone) of the USG in attempting to grapple with the complex issues of CRS and to provide a policy framework within which it could more aggressively promote the CRS industry was the U.S. Commercial Remote Sensing Space Policy (CRSSP) issued by the George W. Bush administration in 2003. On April 15, 2003, the White House issued a fact sheet that summarized the CRSSP.[15] In the year prior to the issuance of this landmark policy document, President George W. Bush directed a review of the national space policy, part of which had to do with CRS issues. The directive was in the form of a National Security Presidential Directive (NSPD)-15, dated June 28, 2002. The Space Policy Coordinating Committee, which was established in 2001, conducted this review and its intent (in part) was to update or replace the Clinton's administration's PDD-23.

Analyzing the verbiage of the fact sheet on the 1994 PDD-23 and contrasting it with the fact sheet on the 2003 CRSSP, it is readily apparent that the policy goals were similar in both documents. However, most tellingly, the 2003 policy led off with the goal of advancing and protecting national security and foreign policy interest, whereas PDD-23's fact sheet placed support and enhancing "US industrial competitiveness in the field of remote sensing" [16] ahead of language on national security and foreign policy. Perhaps this was indicative of a greater foucs on national security vs. industry promotion in the post-9/11 era. The rest of the CRSSP was much more favorable to the U.S. CRS industry than was its predecessor policy, PDD-23. At least the CRSSP went a step further in specifying greater reliance of the USG on commercial imagery data and developing a "long-term, sustainable relationship between the United States Government and the U.S. commercial remote sensing space industry."[17] Essentially, the policy called for a greater degree of industry-government collaboration than heretofore mentioned in similar policy documents. In contrast to PDD-23, CRSSP even went so far as to mention the various benefits of using remote sensing imagery.

In addition to the industry-friendly CRSSP, the USG is to be lauded for effectively implementing its most recent CRS policy by agreeing to massively fund commercial imagery purchases and development of advanced CRS systems through NGA's ClearView and NextView programs. These government programs added resources to previous policy commitments for bolstering the U.S. CRS industry. Although these new USG actions dramatically helped the U.S. CRS industry, they also tended to act as a financial crutch and provided little incentive to motivate industry to expand into non-governmental markets for CRS imagery. According to Joe Francica, Editor-in-Chief and Vice-Publisher of Directions Media, "These [CRS] companies are perhaps too entrenched in their current business model, and they have boxed themselves in to the point where they will find it difficult to think outside of it."[18] Still, financial backing at this crucial time for the nascent CRS industry was absolutely necessary to keep it afloat until it could assume a position of increasing independence from government patronage.

While U.S. CRS laws and policies have generally contained very broad goals and sweeping language, CRS regulations have been more detailed in specifying how such laws and policies are to be implemented. Tasked with formulating and executing CRS regulations, NOAA has spent nearly a decade working out the details of a final set of regulations on the licensing and control of U.S. CRS activities. The original CRS regulations were in place in the late 1980s, but based on the Land Remote Sensing Policy Act and PDD-23, NOAA issued its new set of draft regulations on November 3, 1997. Reviewing those proposed rules and all versions of them since 1997 is a valuable exercise in understanding CRS-related knowledge gaps and the learning curve faced by government and industry alike.

After NOAA issued its 1997 proposed rules (Notice of Proposed Rulemaking or NPRM), a substantial number of public comments and expressions of concern were received from the USG, academia, and the CRS industry (typically, the three main interest groups concerned with CRS issues). Among such comments were expressions of concern over possible restrictions on foreign investments in U.S. CRS ventures, vague shutter control provisions, the definition of "significant and substantial foreign agreements," and confidentiality of the CRS industry's proprietary information.[19] Perhaps due to knowledge voids on the subject matter of CRS but also most likely due to typical protraction of the USG's interagency coordination process, it took NOAA some three years to issue its response to comments on its 1997 NPRM in the form of its 2000 Final Interim Rule.

With the issuance of the 2003 CRSSP, NOAA again found it necessary to issue another proposed modification to its CRS regulations in the form of a May 2005 version (proposed rule). In addition to modifying the language of the proposed regulation to make it more flexible (not tied to specific policies) and to address other issues, extending license review periods, and including the 2000 MOU in an appendix, the proposed regulations expanded the scope of CRS business information confidentiality (proprietary information) to include "foreign agreements and supporting documentation submitted to NOAA."[20] The most salient aspect of the proposed rule is the stated goal of the U.S. to protect "U.S. national security and foreign policy interests by maintaining U.S. leadership in remote sensing space activities and by sustaining and enhancing the U.S. remote Sensing industry."[21] Of course, the USG and particularly DOD and NGA could argue that by "sustaining and enhancing" the U.S. CRS industry through its multi-million-dollar ClearView and NextView contracts, national security is protected and enhanced by providing new and reliable imagery sources for USG use. Although industry (and to some extent, academia and the media) generally agrees with such USG perceptions, it often voices its concerns that advancing and protecting U.S. national security and foreign policy interest can potentially run counter to promoting and sustaining the CRS industry if those interests entail non-business-friendly restrictions on industry, such as shutter control, the 24-hour rule provision, and CRS-related export controls. Specific industry concerns on these matters are discussed in the following subsection on industry's perspectives and actions.

The most recent development in the two-decade-long evolution of U.S. CRS regulations was the issuance of the final CRS regulations on April 25, 2006. A thorough examination of those rules revealed the degree to which the USG was still concerned with national security and foreign policy issues and that DOD and DOS have significant influence and control over the operations of U.S. CRS satellite systems. The final 2006 regulations consist of a summary section, a basic provisions section, and two appendixes (license filing instructions and the 2000 MOU fact sheet). Most notable throughout the document are the terms "national security concerns, foreign policy and international relations" (first iterated in the 1994 fact sheet to PDD-23), which appear thirteen different times in the eight-page summary, fifteen times in the eight-page body of the regulations, and seven times in the two appendixes, for a total of thirty-six times throughout the entire document.[22] That's at least twice for every page of the NOAA regulations. Thus, it is quite apparent that DOD and DOS intended to make it absolutely clear and perhaps felt a need to remind DOC and the CRS industry that (in the post-9/11 environment) national security, foreign policy, and international obligations would continue to play a significant role in the licensing and operation of CRS space systems. Perusal and analysis of this latest set of CRS regulations clearly manifests that divergent perspectives on national security and economic profitability/business competitiveness issues are still highly salient in the politics of U.S. CRS. The dichotomy of these diverse goals and perceptions will probably survive for the foreseeable future, complicating the ability of the U.S. CRS industry to effectively compete in the global market for high-resolution satellite imagery.

Industry Perceptions and Actions

Industry has generally perceived the USG as serving various roles that sometimes are conflictive and counterproductive to industry's efforts to develop profitable and viable CRS businesses in the realm of geospatial information technology. Unfortunately, industry has been in a somewhat awkward position (i.e., highly reliant on the USG as its primary customer for CRS imagery) in expressing its views on what the best policies should be to support its current and future CRS activities. Although industry has welcomed U.S. laws and policies that allow it to operate CRS satellite systems and market its data on a global basis, it has been concerned with what it often perceived as less than business-friendly policies and regulations, such as PDD-23's shutter control provisions (carried over into CRSSP), DOS's export control regimes on technology transfers and CRS component sales and acquisitions, and NOAA's restrictive regulations on instant or real-time imagery dissemination (24-hour rule). Despite these concerns, as U.S. CRS policies and regulations have gradually evolved into more industry-friendly mechanisms for promoting while controlling U.S. CRS activities, industry perceptions and actions have also changed over time.

In the early 1990s, the Policy Act and especially PDD-23 spurred the U.S. CRS industry into action by applying for CRS licenses from NOAA. Following EarthWatch's and EOSAT's licenses in 1993, Space Imaging obtained its license in April 1994 and Orbimage obtained its licenses in May and June of 1994.[23] Although their actions (i.e., applying for licenses and subsequently seeking investments for satellite development and launches) were positive, their perspectives on the new vistas in U.S. CRS were mixed, given the ambiguous commitment of the USG to support industry's future satellite operations and lingering concerns over national security and foreign policy implications of high-resolution satellite imagery.

In reaction to the Policy Act and especially PDD-23, the U.S. CRS industry began applying for licenses in droves. By February 2004, NOAA had granted twenty-one CRS licenses[24] after going through the interagency coordination process. Still, the majority of the licensed firms (excluding DigitalGlobe, Space Imaging, and Orbimage – the latter two now merged into GeoEye) have yet to launch CRS satellites and five of the firms have had their licenses withdrawn due to lack of progress in getting a satellite built and launched.[25] Essentially, the trend has been for numerous firms applying for licenses and relatively few of them succeeding in developing and placing CRS systems into orbit. There are various reasons for these failures, such as inability to obtain adequate funding for building and launching CRS satellites or the demise of the firms themselves. Other less salient reasons for these failures are the subject of an ensuing section of this chapter (i.e., recommendations for future STS research on why CRS satellite companies fail to capitalize on their licenses).

It is important to understand that initial excitement at the prospects of large profits from producing and marketing commercial earth observation imagery during the early 1990s gave way to a more pragmatic realizations in the later 1990s and early 2000s that industry faced significant challenges in building and operating CRS space systems and marketing its imagery data in a highly competitive global marketplace and under fairly restrictive U.S. policy and regulatory regimes. According to a 2001 RAND study, the CRS industry's perceptions of the technical and market risks of successfully building and operating CRS satellites and making a profit from such ventures were less realistic in 1994 than by 2001.[26] Among other factors, the unrealistic expectations were also based on knowledge voids during the early part of the post-1992 transitional period. Fortunately, as if surmounting a knowledge curve, the U.S. CRS industry has recently taken advantage of various venues and forums to fill such knowledge gaps and avail itself of opportunities and the means for informing and educated USG lawmakers, policymakers, and regulators about industry's policy concerns and technical/business risks in operating CRS satellite systems. For example, industry has had several official and unofficial venues in which to present its views on U.S. CRS policies and regulations to promote its interests and activities. The official forum is the aforementioned ACCRES Committee; other unofficial forums have been various conferences, seminars, and symposia that have been sponsored by the USG and private organizations.

Relevant groups associated with CRS have obviously viewed such forums as excellent opportunities for networking and filling knowledge voids. The most prominent of those forums have been ASPRS's annual conferences on remote sensing and photogrammetery, CRS symposiums on CRS sponsored by NOAA (with support from NASA and USGS), and annual CRS Industry Conferences sponsored by the Strategic Research Institute (SRI). Industry has also taken advantage of NOAA's workshops on CRS licensing to fill knowledge gaps on the subject of CRS licensing and operations. The first such workshop was held in September 2005 and the second workshop was held in early 2007. Although such conferences and workshops have been and continue to be excellent forums for educating industry, academia, government, and other stakeholders and interest groups concerned with CRS, the knowledge and contacts gained from these forums need to be translated into concrete actions that will continue to foster growth in U.S. CRS activities and keep the U.S. at the forefront of international CRS.

Knowledge/Perception Gaps: Factors in Policymaking?

Remote sensing is a highly esoteric, multidimensional, and complicated subject. Only a few people in the USG have an in-depth knowledge of CRS technology, operations, and associated policy issues combined. The most knowledgeable officials are in the federal bureaucracy (i.e., NOAA, NASA, USGS, NGA, etc.). The same knowledge void phenomenon is encountered with the even better known Landsat system (i.e., U.S. civil remote sensing satellites), particularly in the Congress. Such knowledge voids were made striking clear during an April 19, 2004 interview of Joanne Gabrynowicz, world-renowned expert on remote sensing law and policy and

Director of the University of Mississippi's National Center for Remote Sensing, Space and Air Law by Jason Bates of *Space News*. Responding to Bates's question concerning the holdup of the development of the next generation Landsat system, Gabrynowicz responded:

> The holdup is basic politics and lobbying. From a political and legal perspective, remote sensing is esoteric. If you were to go into the House or the Senate on any given day and just stop the first five members you meet and ask him or her their opinions on abortion or Iraq or homeland security, they will have an answer. But if you ask them should the Landsat system be in the public sector or private sector, they won't know what you are talking about. It's not something their constituents require them to know about. The irony there is remote sensing is a national activity and a national benefit, but only a few constituents are informed enough about it to influence congressional decisions. You have an asset in the hands of a small community.[27]

Although complexity of CRS issues is one of the challenges to gaining a deep understanding of the manifold aspects of U.S. CRS, that challenge is compounded when there is not a pressing need to seek substantial knowledge about those aspects. As mentioned by Gabrynowicz, lack of a broad constituency for CRS among the general public (in contrast with interest in other issues such as homeland security, the war in Iraq, healthcare, education, taxes, and economic issues, etc.) detracts from a strong motivation to learn the myriad details of CRS. Although issues such as homeland security, stem cell research, illegal immigration, crime, and other hot political topics might come close to or perhaps even exceed the complexity of U.S. CRS issues, they tend to be more highly publicized and perceived by the public to more directly affect the lives of its average citizens. Thus, there naturally tends to be more interest by U.S. legislators and policymakers in overcoming these knowledge acquisition challenges. In other words, while complexity is a significant factor in learning any technology and its socio-political and economic implications (such as CRS), it is only one of several other influential factors.

Desire and motivation to expend a great deal of time leaning the complex details of a given policy issue are very contingent upon what the public knows and is attentive to and what legislators and policymakers feel they need to know to satisfy their constituents. Yet, even with this type of motivation, learning complex subjects can be more daunting than learning less complex ones. In the case of CRS, the average citizen is not exposed to or even significantly comprehends the benefits of such technology as operated by the U.S. space industry. Simply put, until the advent of GoogleEarth, CRS has not been part of (or been perceived to) impact their daily lives. This translates into the average citizen not pressing his/her government representatives to pass various industry-friendly CRS measures. Even with the popularity of GoogleEarth and Microsoft's Virtual Earth, it is unlikely that the novel tool of CRS-derived geo-imagery will be enough for it to become part of the general political landscape in the near future. Essentially, CRS imagery and its various value-added applications are a niche market and will remain that way for the foreseeable future.

The relationship between motivation and knowledge acquisition (discussed above) also applies to (or can occur among) government policymakers and bureaucrats charged with providing input to CRS policymaking. In the domain of the security guardians (DOD, DOS, IC, etc.), bureaucrats and analysts are busy keeping up to date on knowledge and information essential for them to do their jobs that there is little time or incentive to learn all of the esoteric aspects of CRS. In a word, they often do not want to "clutter their brains" with information that is outside the scope of their regular work and is only occasionally necessary when they are consulted on CRS policy issues – a phenomenon reflected in the taxonomy of knowledge voids matrix shown in the previous chapter.

Notwithstanding the low political visibility of CRS compared to other hot socio-economic issues in the U.S., breadth and depth of knowledge of CRS are still essential in understanding how best to promote U.S. CRS activities and in adequately grasping the economic, political (e.g., foreign policy), and scientific implications of CRS for society. This prompts the question: Why are there such knowledge voids concerning remote sensing and its policy ramifications? In answering such a question, it is important to understand that there are numerous factors (complexity being just one) contributing to such knowledge voids. Several people involved in the CRS policymaking process have acknowledged these factors. For instance, reflecting on the complexity of CRS issues at the 1994 Congressional hearing on post-Cold War remote sensing, former Director of Central Intelligence, James Woolsey characterized the balancing act involving national security and commercial interests as "a very complex issue."[28] During the hearing, Woolsey was followed by Keith Hall, Deputy Assistant Secretary of Defense for Intelligence (in the Clinton administration), who stated that developing policies and regulations for CRS was "complex and involves a number of government organizations." [29] Even more emphatic on the complexity of this topic, Robert Gallucci of DOS (following Hall's testimony) made the following statements: "I think it is clear that this issue is one of both immense complexity and importance to the nation...; I would like to thank the committee for this opportunity to discuss this extremely complicated and important issue, …All of us have in one way or another tried to explain to you [Congress] that there are very good reason why this is a hard policy to come to, that it is extremely complex."[30]

Congress has also expressed the same observations on the complexity of CRS policy issues. For example, during the 1994 hearing, Dan Glickman, Chairman of the House Permanent Select Committee on Intelligence (HPSCI), stated: "I mean we're talking about remote sensing and all these kinds of obscure subjects."[31] Further, among hearing witnesses with a technical background, James Frey, President of Litton Itek Optical Systems (Lexington, MA) commented: "…I think we've got to step back and simplify some of these very complex, seemingly complex issues…; the complexity of people worrying about the microscopic security concerns …"[32]

Not only is the subject matter of CRS highly esoteric and complex, it also involves a vast array of legal, policy, economic, technical, organizational, and foreign competitiveness issues. Devising and implementing effective and realistic policies governing the building and operation of CRS systems requires knowledge of multidimensional issues, such as economic viability, national security and foreign policy/obligations, political and bureaucratic cultures and interests, and technical risks, to name a few. Technical issues involve the complexity of designing and building CRS systems, risks in launching and operating CRS satellites, operation of data-downlink ground stations, and CRS imagery processing and dissemination systems, etc. Economic issues involve potential competition from low cost civil remote sensing satellite data; foreign CRS systems and data distribution schemes (distribution to whom, to what extent, and at what price) and foreign government subsidies for CRS programs; and competition from aerial remote sensing systems.

Political and bureaucratic aspects of CRS require an awareness and understanding of institutional cultures and interests, concerns over foreign agreements and partnerships made by U.S. CRS firms, and technology transfer issues (requiring knowledge of the USML and CCL, etc.). National security and foreign policy issues require an understanding of the dual-use nature of CRS. Here, a key question to analyze is: How can CRS technology be used against the U.S. for destructive purposes? This aspect also involves how U.S. CRS imagery can be used by foreign governments, militaries, or adversarial groups and includes knowledge domains related to imagery analysis; imaging system resolution and spectral capabilities; and the potential for using CRS imagery for peacekeeping and humanitarian endeavors, border security, and arms control monitoring, etc.

As can be readily seen, crafting and implementing highly complex CRS policy and regulatory regimes is a very complicated and challenging endeavor. Each of the various components of CRS policymaking involves highly complex and multidimensional aspects or relationships in the CRS policymaking arena. Depicted below in figure 4 is a graphic representation of this complexity and multidimensionality.

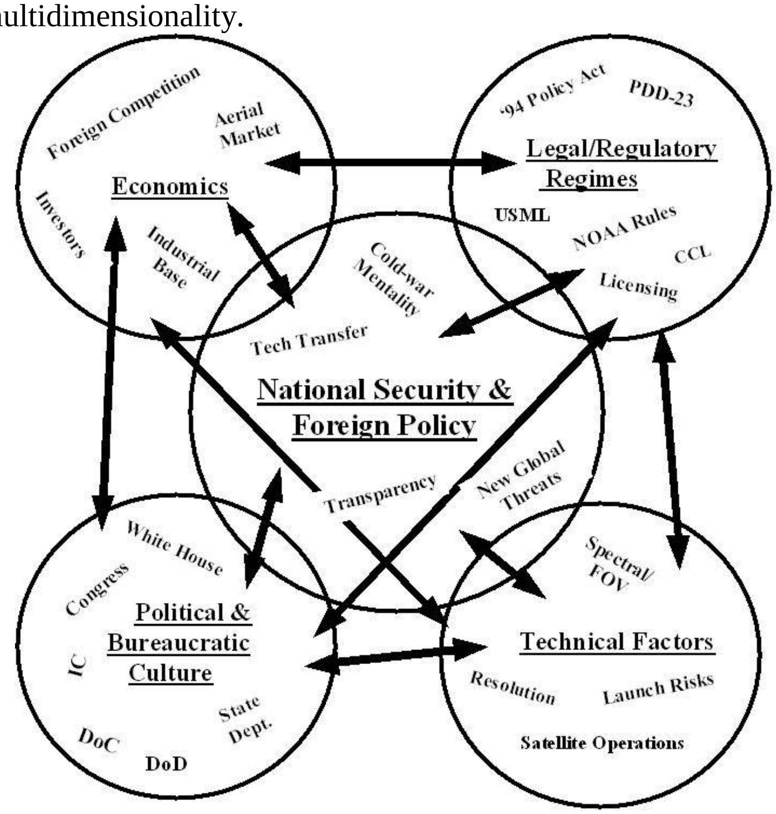


Figure 4.1 – Commercial Remote Sensing Policymaking Environment

The bi-directional arrows indicate mutual relationships between and among various actors, processes, ideas, and technical factors that influence CRS policies and regulations. For example, Congress (in the political and bureaucratic culture circle) needs to understand the technical capabilities of CRS systems to determine their impact on the national security and foreign policy as portrayed by the middle circle. Moreover, various legal and regulatory regimes significantly influence the economic viability of the U.S. CRS industry base included in the economics circle. The central or pivotal circle portrays various aspects of national security and foreign policy issues.

Essentially, Figure 4.1 represents just a few of the multidimensional components of the U.S. CRS policymaking environment and shows how each element in what could be called a large technological system (in Hughesian terms) relate to each other. To visualize the bidirectional relationship environment of U.S. CRS, the following graphic of exemplar scenarios is used to portray (in a linear, textual format) how each component of the U.S. CRS technical, policy, and bureaucratic matrix are influenced by (an thus are related to) each other. Obviously, space constraints do not allow portrayal of every conceivable scenario. Thus, Figure 4.2 (below) takes each component shown in the overlapping circles of Figure 4.1 and arrays them in a linear fashion starting with national security and foreign policy concerns and juxtapositioning those issues with their economic impacts, legal and regulatory ramifications, political and bureaucratic organizations, and the technical aspects of U.S. CRS, in that order, starting with the first row. Thereafter, each component is shifted to the right, resulting in the technical aspects taking the lead in the next serial-scenario process. This order of shifting is repeated until all components have a chance to initiate each scenario. Of course, each of the individual elements or aspects of CRS could be randomly rearranged to determine relational outcomes. All of this is to dramatize the effects of each component on CRS policy decisions on each other and to demonstrate the sheer complexity of this type of policy environment.

SEAMLESS WEB OF CRS INTERACTIONS

National Security/ Foreign Policy *- Concerns over threats to US through misuse of imagery…*	**Economic Aspects** *…lead to dampening of CRS business if foreign CRS operators have more permissive environment…*	**Legal/Regulatory Aspects** *…leads to provisions such as shutter control measures…*	**Political/ Bureaucratic Culture** *…which placates DOD, DOS, IC, and NSC and assuages their concerns…*	**Technical Aspects** *…which leads to building of sensors that do not exceed certain capabilities.*
→ → → →	→ → → →	→ → → →	→ → → →	→ → → →
Technical Aspects *-Critical U.S. components of CRS radar satellite systems (e.g. RADARSAT-2 case)…*	**National Security/ Foreign Policy** *…lead to DOS decisions to reject or delay tech transfer licensing actions…*	**Economic Aspects** *…which leads to Orbimage losing contract and business revenues…*	**Legal/Regulatory Aspects** *…thus, prompting the CRS industry calls for loosening ITAR/USML restrictions…*	**Political/ Bureaucratic Culture** *…resulting in discussions in ACCRES meetings to have USG revisit policies on CRS-related tech transfers.*
→ → → →	→ → → →	→ → → →	→ → → →	→ → → →
Political/ Bureaucratic Culture *- U.S., through DOS, has strong diplomatic ties with Israel…*	**Technical Aspects** *…which leads to realization that high-res CRS imagery can threaten Israeli security vs. its regional enemies…*	**National Security/ Foreign Policy** *…which leads to U.S.-Israeli negotiations to limit imagery of Israel to 2 meters GSD…*	**Economic Aspects** *…awakening other CRS nations to the potential for capturing market share of imagery of Israel…*	**Legal/Regulatory Aspects** *…ultimately leading to the Kyl-Bingaman amendment to the 1997 Defense Authorization Act with competition provisos.*
→ → → →	→ → → →	→ → → →	→ → → →	→ → → →
Legal/Regulatory Aspects - Shutter control provisions of NOAA's CRS regulations….	**Political/ Bureaucratic Culture** *…are imposed when DOD, DOS, or IC pressures DOC to restrict U.S. CRS operations…*	**Technical Aspects** *…by the U.S. CRS industry sending computerized commands to satellites to shut shutter over particular areas of the earth…*	**National Security/ Foreign Policy** *…which could have been exploited by DOD to protect its operations in Afghanistan…*	**Economic Aspects** …potentially harming industry's imagery sales and thus DOD executes "checkbook shutter control" measures….
→ → → →	→ → → →	→ → → →	→ → → →	→ → → →
Economic Aspects *- U.S. CRS is an expensive undertaking, involving hundreds or millions of dollars in upfront investments…*	**Legal/Regulatory Aspects** *…influencing CRSSP to promote the industry by encouraging the USG to purchase CRS imagery…*	**Political/ Bureaucratic Culture** *…which impacts NGA who institutes ClearView/NextView programs…*	**Technical Aspects** *…resulting in NGA contract funding programs for next-generation satellite imaging systems…*	**National Security/ Foreign Policy** *…again causing national security concerns unless two-tier purchasing program is implemented.*
→ → → →	→ → → →	→ → → →	→ → → →	→ → → →

Figure 4.2 – Interlocking Scenarios involving the Multifaceted CRS Policy Arena

Obviously, complicated socio-technical relationships are not the only factors in CRS knowledge voids. As discussed in a previous section, lack of motivation or incentives to acquire substantial amounts of knowledge concerning the highly esoteric aspects of CRS are also at fault. Other factors consist of too much information or what is knows as the "information glut" and lack of information availability or interpretability. In the case of a CRS information glut, there is so much information on CRS issues that it is difficult for even scholars and experts to maintain currency and stay abreast of all the dimensions of CRS developments. Working with various agendas, Congress and space policymakers would be even more challenged to become familiar with or grounded in the myriad aspects of CRS, particularly in its global context.

The flip side of the CRS information glut involves unavailable or inaccessible foreign CRS information or the inability to interpret such information. Often CRS observers lament the fact that much of the information on foreign CRS laws and policies are not well known to the U.S. CRS policy community. Although RAND and ASPRS provided a fairly good snapshot of foreign CRS activities and policies in their 2001 book, that information is rapidly becoming outdated. Fortunately, such information has been updated, in part, by Gabrynowicz in a study on selected foreign CRS laws and policies.[33]

Still, even if CRS policy-relevant data and information is uncovered through extensive research efforts, many important reports on foreign systems and policies outside of Europe and India (e.g., Russia and Asia) might be in a foreign language that would require meticulous translation by one who is familiar with the technical aspects of CRS. Yet, despite these barriers, knowing what other nations are doing in the realm of CRS is extremely important to both the U.S. CRS industry (to stay competitive) and to U.S. CRS policymakers (to craft and implement CRS laws, policies, and regulations that help industry stay competitive).

Macro/Structural Knowledge Gaps

CRS-related knowledge voids can be organized into various macro categories. Numerous examples of CRS-related knowledge voids are identified and analyzed under the following subsections categorized as legal/policy aspects, technical aspects, business/economic aspects, and organizational aspects. Here, it is important to emphasize that identification of knowledge voids concerning the multidimensionality of CRS policymaking is not to be taken as a harsh criticism. Knowledge voids are a fact of life and all of us have them in one form or another and to one degree or another. Elucidating CRS-related knowledge voids is done simply to point out the complexity of the esoteric policy world of CRS. It is also instructive to see how such errors or knowledge voids potentially affect the perceptions of lawmakers and policymakers in determining how best to deal with the dual-use nature of U.S. CRS activities on a domestic and global stage.

Legal/Policy Aspects

Remote sensing satellite operations have a myriad of legal and policy ramifications. That said, gaining and maintaining vast reservoirs of knowledge in the legal and policy domains is extremely daunting and challenging. On the legal front, compliance with CRS laws, policies, and regulations brings up some interesting knowledge void issues. Often the literature on U.S. CRS laws and polices reflect knowledge gaps concerning major U.S. legislation promoting and controlling CRS activities. Several of these types of knowledge gaps center on inaccurate identification of specific CRS laws and policies and the periods in which they were established. Confusing titles of major public laws related to CRS might seem trivial, but it is important to correctly distinguish between the 1984 Land Remote Sensing Commercialization Act and the 1992 Land Remote Sensing Policy Act, since their provisions are different, they had somewhat different objectives, and they occurred in different time periods and political environments.

PDD-23 is also the source of common misperceptions or misstated terminology in much of the literature on U.S. CRS policies. Actually, PDD-23 is not a publicly available document and anything written about it in public sources is or should be derived from the fact sheet summarizing PDD-23, not from PDD-23 itself. Thus, any quotes or citations of, or references to, the language of PDD-23 actually come from the fact sheet entitled "Foreign Access To Remote Sensing Space Capabilities." This differentiation is important in understanding what the PDD-23 may or may not say, and what the fact sheet says.

Another problem with knowledge deficiencies concerning CRS legal and policy matters is incorrectly citing documents or using incorrect acronyms complicates digital searches for the important CRS policy decisions and directives, particularly when using Internet searches. Moreover, this pattern is the result of the phenomenon of knowledge void propagation discussed earlier in this dissertation. At the least, it can detract from the credibility of research findings or can cause one to question how steeped researchers are in CRS legal and policy regimes and/or how many other inaccuracies are contained in the CRS policy-related literature. Specific examples of statements based on inaccurate knowledge of CRS legal and policy issues are contained in Appendix H of this dissertation.

Technical Aspects

In the domain of CRS, minor knowledge voids or unintentional research mistakes are not just confined to the legal and policy arena; they also extend to the technical aspects of remote sensing and point to the complexity of that field. Occasionally, policymakers or commentators who lack a solid technical background in remote sensing capabilities express concerns about privacy issues (i.e., that earth observation satellites can or someday could track individuals anywhere on the Earth). As an example of knowledge voids concerning CRS technical capabilities, Matthew O'Connell (then CEO of Orbimage), commented on a conversation with a U.S. congressman and the latter's question about whether a very high-resolution satellite could image and ostensibly identify individual human beings. According to Joanna Glasner of *Wired Magazine,* who conducted the interview, "O'Connell recalls delivering this disappointing news [i.e., the limitations of CRS systems] not long ago to a congressman, who wanted to know if it was possible to see prisoners in North Korean prisoner of war camps using satellites. O'Connell replied: 'Congressman, we're flying overhead, so the best you'd see is the top of someone's head.' "[34]

Additional confusion or faulty knowledge can also come from period-specific claims of remote sensing system capabilities. In a 1988 study on remote sensing capabilities, Ann Florini wrote that radar (likely considering radar satellites at the time) "requires a great deal of power–usually provided by a nuclear reactor."[35] Technically, such would only be the case when referring to older Russian radar imaging satellites. While the Soviet Union developed and operated a series of nuclear reactor-powered radar satellites, known in the West by the term RORSAT and codenamed by the Russians as " US-A (or Upravlenniye Sputnik Aktivny in Russian), US-AM and, later, RLS,"[36] the nuclear reactor-powered models were only operated between 1971 and 1988.[37] U.S. satellites are not operated by nuclear power.[38] Even Canada's first synthetic aperture radar satellite, Radarsat-1, was powered by the sun using solar panels.[39]

Often knowledge voids reflect a mixture of inaccurate statements on the technical parameters of particular systems and their specific nomenclatures. Highly detailed examples of such knowledge gaps are covered in Appendix F. A less complicated example of such knowledge voids can be seen in a November 1999 article in the journal of the Institute of Electrical and Electronics Engineering (IEEE), *Spectrum*, which contained several misstatements following the successful launch of the world's first high-resolution CRS satellite, Ikonos. Although highly informative, the article contained numerous factual errors concerning CRS activities and systems. According to the article's author, James Oberg, the Landsat observation satellites of the 1970s had 50-meter resolution capabilities.[40] Actually, the resolutions of Landsat systems at that time were 80-, 80-, and 30 meters, not 50 meters. Further, it was reported that, "In the '90s, both India and Israel launched systems with 5-meter resolution."[41] Although India's IRS satellites boasted around 5- to 6- meter resolution, Israel did not even have a civil observation satellite in orbit in the 1990s. Moreover, the only operational Israeli military satellite in the 1990s, Ofeq-3, reportedly had about 1.8-meter resolution.[42] Perhaps Oberg was thinking of another Israeli system called "Diamant (David)" that was being jointly developed with Germany in 1995 with a resolution of 5 meters, but the system was still in the developmental stages by at least February 2003.[43]

Although these types of knowledge gaps might be deemed inconsequential in the grand scheme of CRS policymaking, it is important to accurately know the technical parameters of foreign CRS satellite systems to formulate effective CRS laws and policies that allow U.S. systems to compete in the global marketplace. Many of the USG's decisions for CRS license applications are premised on knowing the precise imaging capabilities of foreign CRS systems. If a foreign system currently offers a 5-centimeter panchromatic imaging capability, then U.S. CRS policies and regulations would support the issuance of licenses of U.S. system to at least that same capability.

Business/Economic Aspects

Although knowledge gaps in understanding the legal and technological aspects of CRS seem to abound, a less obvious but still important aspect that also seems to generate confusion is the economic dimension of the CRS. For example, during the 2006 CRS Satellite Symposium held Washington, DC, panel moderator, Patricia Maloney (Director of the Economic and Market Analysis Center of the Aerospace Corporation) characterized the extent of the USG's knowledge of the CRS business by repeating the supposedly oft-asked question by many USG officials: "You mean there is a [CRS] business?"[44] Such questions often reflect a lack of understanding of the business and economic aspects of CRS by USG officials grappling with CRS licensing and policy issues.

This brief subsection provides examples of these types of structural or categorical knowledge voids. For instance, writing in 2001 about the "Open Skies" dimensions of remote sensing, Mark Gabriele, then a RAND policy analyst, described the costs of building 1-meter earth observing systems as ranging in the tens of millions of dollars. According to Gabriele, "…estimates of the cost of a commercial remote sensing satellite with resolution in the 1-m range vary widely, but by all accounts it is an expensive undertaking ranging well into the *tens* [italics mine] of millions of dollars."[45] This statement is somewhat misleading and could cause CRS policymakers to assume that CRS satellite can be constructed on the cheap. Although some CRS satellites (particularly minisats) can be developed and produced for a few tens of millions of dollars, more accurately, the costs can range into the hundreds of millions of dollars. Ironically, the 2001

RAND study commissioned by NOAA reported that small CRS satellites would cost "millions or a few *tens of millions* [italics min] of dollars," but that more conventional systems cost *hundreds of millions* [italics mine]".[46] According to Florini and Dehqanzada, high-resolution satellite sensors and spacecraft construction costs range from $45 to $300 million.[47]

It is widely reported that, when adding in insurance and launch costs, the figures can range from around a $100 to $500 million. The problem with these knowledge gaps is that they can potentially confuse those in the CRS policy arena and perhaps lead them to conclude that building, launching, and operating high-resolution (1-meter) CRS systems is less than a significantly expensive undertaking. Moreover, such faulty assumptions can lead to misperceptions concerning the negative impact of overly restrictive CRS laws and regulations on CRS profit lines. To highlight the misunderstood economics of CRS, J.D. Wilson of *GeoWorld*, wrote in October 1998, that, "The combined investment on high-resolution satellites may reach $700 million before the companies get their satellites in orbit, and they must bear these massive costs before delivering any product."[48]

One source of knowledge gaps concerning satellite costs is likely confusion between owner costs (i.e., construction, launch, insurance and operations) and user costs (i.e., independent tasking of satellites for designated customers). Specifically, the aforementioned *Spectrum* article discussed the exclusive Israeli program that allows customers to task EROS satellites for a substantial fee. According to James Oberg, "… since buying exclusivity from only one of several different satellite systems could thus cost in the range of tens of millions of dollars."[49] This phrase apparently has been picked up by other writers on the politics of remote sensing and subsequently confused with the cost of building high-resolution satellites. Instead, this "tens of millions" refers to the exclusivity agreement fees per year for customers to task the Israel EROS satellites, not what it costs to build and launch high-resolution CRS satellites, which are in the hundreds of millions of dollars.

Organizational/Institutional Aspects

Given the extreme complexity of the political and technological aspects of CRS, it is not surprising to come across a significant number of factual errors in the literature on CRS and equate them to superficial gaps in knowledge of the subject. The situation of U.S. legislators and policymakers not being familiar with foreign CRS systems can be reversed. Often, foreign government officials writing about U.S. CRS systems can also be confused with the myriad details of the immense and complex subject of CRS. Specific examples of such cognitive failings are detailed in Appendix G of this dissertation.

This particular category of knowledge gaps generally involves unfamiliarity with or misidentification of CRS organizations and system nomenclatures. Such knowledge gaps are most likely due to the sheer number and complexity of CRS organizations and satellite systems, particularly when they include international organizations and systems in addition to those in the U.S. CRS industry. Along with foreign CRS legal and policy regimes, this particular knowledge void category is one of the most striking aspects of structural knowledge void problems for U.S. CRS policymakers and regulators attempting to understand the global environment of competitiveness for U.S. CRS satellite firms. As depicted by figure 4.1 (previous subsection), there is a substantial number of players in the U.S. CRS arena involving multiple relationships. Adding in CRS organizations from almost a dozen foreign nations (involved in developing, operating, funding, and regulating CRS systems) increases the scope of essential knowledge required to keep the U.S. in a competitive position vis-à-vis medium- to high-resolution observation satellites. This is one of the reasons why NOAA commissions studies to learn more about the organizational aspects of international CRS activities.[50]

Although a significant amount of research on foreign CRS satellite systems and policies have been undertaken by such organizations as RAND and ASPRS on the business and government organizations associated with CRS systems (which adequately fill many of these types of knowledge voids), the information in these studies is rapidly becoming outdated and new knowledge-generating studies need to be undertaken as recommended in a latter part of this chapter. In addition, detailed analyses of knowledge voids concerning CRS organizations and systems are contained in Appendix G.

Analysis of Knowledge Voids (Factors in Policymaking?)

Chapter 1 provided some hypothetical cases of how knowledge voids can contribute to faulty perceptions leading to undesirable actions. This subsection considers the possible connection between knowledge voids and perception gaps and relates that phenomenon to CRS policymaking and regulatory decisions. It also identifies and discusses several likely causes of CRS knowledge voids. Obviously, the complexity of CRS-related policy issues (e.g., technical, economic, political, national security, foreign competition, etc.) as demonstrated in the previous section, is a significant factor in CRS knowledge voids. Yet such knowledge voids are also the result of other factors such as lack of time, opportunity, or motivation to amass the requisite knowledge to make the most informed and effective policy and regulatory decisions for U.S. CRS operations. In the case of motivation deficit, certain actors tend to avoid or reject additional knowledge on CRS issues that potentially threaten or alter their strongly held perspectives, interests, and policy positions. Such was the case with the Reagan administration (particularly, OMB) that wanted to believe that CRS could become economically feasible in the hands of business and thus would solve some of the USG's budgetary problems. In that case, policy and budgetary objectives cause administration officials and Congress to ignore evidence (aka knowledge) that conflicted with their perspectives and interests. This phenomenon is often called cognitive rigidity.[51]

Lack of motivation to acquire in-depth knowledge of complex CRS issues can also be tied to the perception of members of Congress that the majority of their constituents are not that interested in CRS and are not pressing for particular stances on how best to promote or regulate CRS activities. Often, the average citizen is more interested in issues such as jobs, healthcare, education, terrorism, and other socio-economic problems than the esoteric field of CRS. Furthermore, to address all of these issues, Congress and the executive branch are extremely busy and CRS occupies a very small portion of their legislative and policy agendas. Even Congressional committees that deal with CRS issues such as the House Committee on Science and Technology and the Senate Committee on Commerce, Science and Transportation[52] are extremely busy dealing with other aspects of space and technology activities besides just U.S. CRS.

A third but major cause of knowledge voids in CRS policymaking can be seen as restrictions on information flow between industry and government. Industry would like to educate government policymakers and regulators on their business impediments (particularly those created by overly strict CRS regulations), but naturally have concerns about the security of their proprietary information. On the other hand, the USG (particularly national security institutions) tend to protect highly sensitive national security and foreign policy information. Fortunately, this traditional barrier to free flow of information between the two sectors has been eased by forums such as the public and non-public sessions of ACCRES.

The greatest rift in perceptions that have molded U.S. CRS policies is between perspectives on, and advocacy for, openness regimes in CRS vs. security and foreign policy concerns and concomitant restrictions on the U.S. CRS industry. In the openness camp, we generally find the CRS industry, significant parts of academia, several members of Congress, and various officials in the executive branch (e.g., DOC, DOI, etc). Here, it is reasonable to conclude that this camp's perspectives and interests tend to focus on a CRS control regime that is the least restrictive. Such perspectives often drive actions to lobby for policies and regulations that are most favorable to the CRS industry, but could also be viewed by some as being unfavorable to the nation's security and foreign policy community.

In the national security and foreign policy camps, we generally find DOD, IC, and DOS, some members of Congress, NSC, and perhaps even the Department of Homeland Security (DHS). DHS is a fairly new organization and it might be too early to examine and analyze trends in its thinking on CRS policy. The knowledge resources of such officials or organizations on how their interests could be threatened or damaged by the misuse of CRS are substantial. However, such officials or organizations generally do not deal in the business, financial, and economic aspects of CRS, and therefore, it is logical to assume that their perceptions on how best to regulate and control CRS are skewed toward the side of restrictions and limits on CRS operations. Such perspectives, coupled with organization missions, cultures, worldviews, interests, and other sociological factors (fertile fields for STS research) could explain why organizations such as DOD, DOS, or the NSC, etc. might desire to have a fairly restrictive CRS policy and licensing regime such as shutter control, tiered licenses, export controls, 24-hours rules, foreign investment rules, etc. and why they would lobby Congress and the administration for fairly restrictive CRS policies and regulations.

USG officials in the national security and foreign policy establishment have the responsibility for making decisions on CRS licensing applications, license amendments, foreign agreements, and possibly suppression of satellite operations during international crises, etc. In order to reach timely decisions, USG officials would need to coordinate CRS-related actions with other officials within the same office or agency or external to that office or agency, many of whom might not even have the same knowledge base as the official seeking to coordinate decisions. In other words, it is difficult to imagine that all key individuals in the coordination loop are as familiar with the CRS-related economic and business ramifications of their decisions as they are with the national security and foreign policy dimensions of CRS. Thus, one could conclude that decisions arising from interoffice or interagency coordination of CRS policy/regulatory issues could be delayed or avoided altogether based on not having a vast reservoir of knowledge on the subject matter at hand. It's possible that action items could remain at the bottom of in-and-out boxes for long periods of time and result in inaction, as far as the CRS industry is concerned.

On the other side of the policy divide, the U.S. CRS industry does not have the resources or mandate to become highly cognizant of the national security and foreign policy implications of its business operations and practices on a global scale. CRS industry officials must simply rely on the advice provided to them by USG officials dealing with these areas, usually in non-public meetings or forums. Since the CRS industry is mostly focused on generating profits from its business (satellite) operations and strategizing about how to grow its marketing operations to encourage future investments for future CRS satellite systems, its knowledge base is economically oriented and tend to create perceptions that could be characterized by some as pro-business at the expense of national security or foreign policy concerns. Here, industry is in a more difficult position than the government. There is only so much knowledge that it can gain on the national security/international relation side of the issues – only that information which industry officials are authorized to obtain from their government counterparts. Not having full access to information pertaining to all aspects of the national security or foreign policy issues, it is reasonable to assume that industry's perceptions include the notions that various CRS polices are antiquated, unproductive, or "byzantine" to use the term of Mathew O'Connell during an October13, 2006 panel session (CEO Panel) of the 2nd Commercial Remote Sensing Symposium.[53] In most cases, the U.S. CRS industry simply has to trust or rely upon the USG to be the experts in these types of issues. Based on its viewpoints on how it understands the economic ramifications of restrictive regulations, the U.S. CRS industry is currently calling for reconsideration or relaxation of the 24-hour rule (i.e., not allowing dissemination of high-resolution CRS imagery to non-USG entities or USG-approved foreign governments until it has aged at least 24 hours), which is in place due to the perspectives of the national security camp.

When dealing with knowledge voids, perception gaps, and flawed CRS policies, it is instructive to consider a slightly parallel theme advanced by Charles Perrow concerning accidents in technical systems.[54] Perrow's concepts and descriptions of non-linear interconnectedness in complicated technical systems[55] are similar to the complex interconnectedness of CRS such as its political, regulatory, organizational, economic, international, and technical dimensions (recall Figure 4.1). Each of these dimensions could be considered as subsystems (consisting of components). For example, the international dimension of CRS can be considered a subsystem of global CRS competitiveness and a particular country's CRS program can consist of a component of the overall global system (which affects U.S. CRS economic competitiveness and the policies and rules that promote and control it). The complex system of CRS policy can be seen as both linear and non-linear; linear in the relationship of one component to another such as transfer of CRS technology being directly linked to the USML (recall figure 4.1) for example, but non-linear in the potential interconnectedness to that relationship and other components such as the foreign policy domain and U.S. relationships with its allies and other foreign nations, for example (which determines whether CRS technology transfers will be approved by DOS).

The more dimensions there are to the high-tech systems of U.S. CRS, the more complex and complicated those systems are and the more knowledge voids there can be about them. In another example, the bureaucratic dimension of CRS policymaking and rulemaking can also be seen as a subsystem of CRS. This includes the actions of USG agencies, departments or working groups involved in U.S. CRS policies, regulations, licensing, imagery acquisition, and shutter control decisions. Each subcomponent (or representative) in a CRS policy-related working group could also be considered a system component. Extensive knowledge of the interactions of these components and subsystems is critical to understand the impacts of bureaucratic decisions on U.S. CRS.

Armed with the foregoing knowledge, we might ask: Can knowledge voids be eliminated or prevented, or are they simply an inevitable phenomenon in the complex world of CRS policymaking? This dissertation argues that, although it is ideal to eliminate or prevent such knowledge voids from occurring and thus adversely affecting CRS policymaking, faulty or insufficient knowledge on this subject is a fact of life and probably inevitable. If one considers U.S. CRS policies and regulations and the debates, discussions, and perceptions about them to be similar or analogous to a complex mechanical system, then it is logical to assume that the more complicated the legal/policy/technological system is, the more prone it is to the occurrence of knowledge gaps. Essentially, Perrow's system accidents (disruptions) can be equated to policy failures in the area of U.S. CRS.

Perrow discusses minor and major accidents or incidents and the linkage between their causes and effects. The characteristics of these accidents (i.e., minor and major accidents) can also be applied to knowledge voids. When it comes to CRS issues, there are minor or micro knowledge voids as well as macro or major knowledge voids. The former are isolated or anecdotal incidents of knowledge gaps or incorrect knowledge, whereas macro knowledge voids are more broad, thematic, and structural in nature. Individual examples of micro knowledge voids have already been extensively documented throughout this dissertation. Collectively, these micro knowledge voids add up to macro/structural knowledge voids discussed in the previous subsection. Although the openness-security divide might never be closed entirely, it would be helpful if industry or other CRS observers or interested persons/organizations could figure out a way to close this structural knowledge-perception gap by devising a system or mechanism (means) that would satisfy both camps. Such is one of the topics of the recommendation section of this chapter.

What Would Have an Informed CRS Policy Looked Like?

It is always interesting to speculate or conjecture on what form of CRS laws, policies, and regulations might have been crafted had there been an absence (or lesser degree of) CRS-related knowledge gaps during the twenty-three-year history of U.S. CRS policymaking. As early as 1984, the first policy that could have been different or eliminated altogether was the 1984 Land Remote Sensing Commercialization Act. Two years before passage of the Commercialization Act, OTA had cautioned against commercializing the Landsat program in a lengthy study (part of which dealt with remote sensing) entitled *Space Policy and Applications*.[56] The study made it clear that a commercialized Landsat would require substantial government subsidies for at least five to ten years (i.e., 1982-1992 at the outside).[57] Continuing federal sponsorship of the program made the best sense, but acting on that knowledge would have required the USG to have foregone its policy to accelerate commercialization of the Landsat system. Moreover, acting on such knowledge would have clashed with the administration's desire to find ways to reduce government spending on programs it felt the private sector could take over. Still, assuming this knowledge and logic reigned over interests in spending cuts, the USG would (or should) have either delayed commercialization or waited until it was a viable option for land remote sensing.

Given advance warning that competition in land remote sensing by other foreign nations (France, Russia, India, etc.) was on the horizon and given the fact that U.S. technological leadership was very important to politicians of the day, the Commercialization Act might have been passed by something one might have called the "Landsat Support Act," which would have guaranteed continued government sponsorship of the program until the market was ready for viable commercialization of land remote sensing in the U.S. (which would have been in the post-1990s era). Of course, Congress and the Reagan administration would have had to of had deep knowledge of and appreciation for the tremendous value of Landsat imagery data to environmental and scientific community and to other civil users. Ironically, such information was clearly articulated throughout the OTA study.

It is also important to understand that such knowledge (or advice) was repeated by OTA in 1984 just prior to passage of the Commercialization Act that year in the form of 141-page technical memorandum entitled *Remote Sensing and the Private Sector: Issues for Discussion*.[58] Although highly detailed and technical, the OTA study made it clear in its executive summary that, for the commercialization plan to succeed, Congress would need to continue to provide massive subsidies to the private sector "until the market expands [expanded] substantially"[59] and that it would cost the government as much money to support commercialization in the near- to mid-term as it would cost if the government operated the system itself.[60] Armed with this knowledge, Congress and the administration would (or should) have pushed its commercialization policy down the road (its often easy to procrastinate on difficult issues and decisions) to a more opportune time and instead passed the notional "Landsat Support Act" in 1984 or perhaps a few years later. Of course, that assumes the USG was willing to continue to fund the program in its budget cutting environment (a big assumption) for several years to come. To do this, Congress and the administration would have had to really understand the tremendous value of earth observation data and the political importance of maintaining its leadership position in the world of remote sensing vis-à-vis newly emerging land remote sensing nations. To reiterate, such knowledge was clearly offered by the 1984 OTA study, as well as by four other studies conducted or commissioned by NOAA as previously mentioned in this dissertation.

Although hindsight is said to be 20-20, if legislators and policymakers were sufficiently knowledgeable and astute at the time, the notional "Landsat Promotion Act" would have: 1) emphasized the national interest in remote sensing, 2) committed funding to the Landsat program to keep it operating and promote the development of future, advanced systems, and 3) included a section in the Act that commercialization was still a long-term goal of the USG and would be addressed at a latter time (i.e., when the market and IT infrastructure were in place to support such an effort as communicated by future studies by the OTA and other study groups).

Fast forwarding to the mid- to late-1980s, Congress and the administration would have realized it made a good choice in view of the fact that the French would launch its SPOT satellite, the Indians would launch its IRS satellite, and the Russians would began marketing 5-

meter imagery data on the international market. Even more optimistically, Congress would have devoted enough funds to have remote sensing systems developed and launched to effectively compete with these foreign systems. If the French and Indians could do it, there is probably little reason why the American could not have done it, as well. It simply required knowledge, commitment, and funding.

In the early 1990s, the market for remote sensing data was beginning to develop and the IT infrastructure was at a point where it could have supported commercial land remote sensing systems. Armed with and acting on that knowledge, the 1992 Land Remote Sensing Policy Act would (or could) have been written as the "Commercial Remote Sensing Act (CRSA) " (a slight variance from the 1984 title) and contained the same provisions as it does today for the CRS industry. All that was needed was to cut and paste into the CRSA most of the same verbiage contained in the 1984 Commercialization Act. In addition, the Landsat Promotion Act would or could have been updated (amended) to be in synch with the times in the early 1990s.

Of course, the notional "Commercial Remote Sensing Act" of 1992 would have had to be followed by PDD-23, so we now turn to what that policy might have been, given more knowledge of all the various dimensions of CRS in the mid-1990s. Of course, playing armchair quarterback, I have to assume that another excellent OTA study on remote sensing would have been published about a year earlier (in late 1993 following passage of the notional Commercial Remote Sensing Act instead of September 1994 when it was actually published) to provide the requisite knowledge that would result in a somewhat different version of PDD-23. According to recommendations in the 1994 OTA study entitled *Civilian Satellite Remote Sensing: A Strategic Approach*,[61] Congress would need to have supported the industry and enhanced its competitiveness by: 1) directing federal agencies to purchase and use commercial imagery (an actual provision in the 2003 CRSSP), 2) directing federal agencies not to unfairly compete with the CRS industry, and 3) calling for increase support for advanced technology in remote sensing that benefited both the government and private sectors.[62] Further, had the national security community had more knowledge about the commercial and market (competitiveness) aspects of CRS and not allowed their closed-information perceptions to cloud such knowledge and logic, PDD-23 might not have its "shutter control" provisions. Hindsight is always easier than foresight, but PDD-23's shutter control provisions have not been implemented in a single instance in the last 13 years since that policy was issued. Thus, that provision was probably not necessary in the 1994 policy, although it is what I consider a "feel good" provision for supporters of its inclusion in the policy document. Instead of the shutter control provision, PDD-23 (and the subsequent 2003 CRSSP) might have contained a previously discussed (alternate) measure called "checkbook shutter control." In other words, a more informed and effective provision (that would satisfy the national security camp) would have been to allow the USG exclusive purchasing rights over any imagery taken of areas of conflict, military operations, or activities of foreign policy concerns. This would have been beneficial in a couple of ways; first, it would have ensured that the U.S. CRS industry would not have lost revenue from such "restricted" imagery and, second, it would cause the USG to think twice before exercising these exclusive buyout options if it wanted to not spend too much money. Of course, the only drawback to this notional provision is that it would have still hurt other non-U.S. customers of U.S. CRS imagery. Moreover, it could have run into problems with the U.N. Principles of sharing civil (and probably commercial) imagery data to any sensed state.

PDD-23 would have been about the same as it was when issued by the Clinton administration, but it might have contained provisions that called for more active and positive support to the U.S. CRS industry in the form of imagery purchasing agreements and partnership funding of future CRS satellite systems. Essentially, with less knowledge voids and more prescient capabilities, CRS stakeholders at the time (mid-1990s) would have crafted PDD-23 so that it looked more like the 2003 CRSSP. Obviously, this is based on the assumption that all stakeholders realized the value of CRS (and that means they needed much more technical knowledge of CRS), realized the challenges that would be faced by the nascent CRS industry in a dynamic and completive global marketplace, and were sufficiently committed to providing adequate government funding to see U.S. CRS succeed. Finally, if there were fewer knowledge voids and better knowledge on the complicated and multifaceted aspects of CRS (and of course if other factors were cooperative), the 2006 NOAA CRS regulations would not have taken twelve years to finalize and they would have been much more industry friendly.

So what does all this mean? Put differently, what difference do knowledge void indicators make when it comes to crafting and implementing effective CRS policies? As we can see from the forgoing arguments or after-the-fact prognostications, deeper understanding of CRS issues could have resulted in different policy decisions. However, it is important to understand that many other factors (besides knowledge and understanding or lack thereof) come into play when it comes to influencing policy perceptions and decisions, such as personal interests, institutional cultures, organizational goals and missions, and even motivations or disincentives to acquiring requisite knowledge for informed policymaking. As adeptly put by Janet Abbate (faculty member of Virginia Tech's STS program), certain people tend to be overwhelmed by the vast amount of knowledge (in this case with CRS issues) and thus either avoid acquiring the difficult knowledge altogether or do not know what part of the information/knowledge overload that they need to selectively acquire.[63] This might have been the case with the U.S. politicians and bureaucrats deciding on whether or not to commercialize Landsat in the early 1980s. We know that the Reagan administration either avoided or ignored adequate knowledge provided by various studies on the proposed commercialization of Landsat leading up to the passage of the ill-fated Commercialization Act. Here, the bottom line is that knowledge voids played a role (albeit not an exclusive role) in defective CRS policymaking and better knowledge might have made a difference in the policy choices at the time. To avoid repeating these mistakes in the future, CRS policy recommendations are discussed and offered in the next section.

Policy Recommendations

As will be detailed in this section, one of the key recommendations for this study is to eliminate CRS-related knowledge voids that hinder effective CRS policymaking. In offering this recommendation, it is important to understand the nature of knowledge voids and how they influence contentious policy debates. Lack of knowledge (or knowledge gaps) and conflicts of interest in promoting and regulating U.S. CRs are two separate issues. Increasing knowledge on CRS issues will not necessarily eliminate competing interests and incompatible values concerning CRS policies and could even intensify such policy conflicts. The latter would occur should those who have strongly held views and perceptions on CRS use increased knowledge to bolster their policy positions against the interests of others with opposing policy views. Thus, attempts to fill knowledge gaps are a double-edged sword. In some cases, filling knowledge voids for those who share or should share common interests in U.S. CRS activities (i.e., industry and NGA, for example) should help bridge perception gaps and policy differences to arrive at a common goal (i.e., promotion of a viable U.S. CRS industry). Yet, one inevitably runs the risk of providing additional knowledge and having it used to fuel or exacerbate competing interests and values of highly polarized groups (e.g., CRS industry and advocates for more business-friendly regulations vs. those in Congress and the administration who argue for tight restrictions on CRS activities for national security and foreign policy purposes). In this case, using increased knowledge to support one's position can make it more difficult to reach compromises on U.S. CRS policies. Still, it is a risk that is worth taking. While competing interests and incompatible values might not be eliminated by better knowledge, eliminating CRS knowledge gaps can help one side gain a greater appreciation for the other side's perspectives and interests and at least result in more informed policy debates on important CRS issues.

Several recommendations for improving the prospects for a viable CRS industry in the U.S. and internationally have been offered by prominent institutions and organizations. This section mentions the most notable recommendations and then concludes with alternate suggestions for improving the policy and regulatory environment for U.S. CRS. In 2001, RAND conducted a study for NOAA on CRS industry risks and offered several policy recommendations to DOC on how to reduce the risks faced by the U.S. CRS industry in successfully building and operating CRS satellite systems and competitively marketing CRS imagery data. While the recommendations were sound, they were fairly general and nonspecific in nature. Among the key policy recommendations were that DOC (NOAA) should:

> … continue to create a policy and regulatory environment conducive for encouraging the U.S. CRS industry; continue normalizing its regulatory process for CRS space systems; study and monitor the aerial CRS industry, broader geospatial industry, and foreign CRS systems and markets; and dedicate more internal DOC resources to understanding its responsibilities for licensing and regulating the CRS industry.[64]

Interestingly, two of the four broad recommendations dealt with filling knowledge voids concerning the policy and economic dimensions of CRS. Since the 2001 RAND study, other recommendations have also been offered to help promote the U.S. CRS industry (key among them were recommendations that resulted in CRSSP). Further, ACCRES and unofficial CRS forums have provided many policy recommendations to the USG to help make U.S. CRS more successful and commercially viable. Most recently, the U.S. CRS industry has called on the USG to extend and communicate its financial commitment to supporting industry's CRS activities and to loosen its restrictions on CRS technology exports and the so-called 24-hour rule.[65]

Even international organizations have offered recommendations for national governments to make CRS laws and policies more supportive to the CRS industry. For example, addressing issues regarding space policy (including international remote sensing activities), the Organisation for Economic Co-operation and Development (OECD) pointed out that the role of governments is a key component in shaping and directing the future of the space industry.[66] In a 2005 study of the international space industry, OECD concluded that "existing space-related laws are not business friendly."[67] Even more germane to a key thesis of this dissertation (i.e., knowledge gaps), OECD emphasized that "decisions regarding space are not always taken with a full understanding of the issues at hand."[68] As a result, OECD made several recommendations for improving space activities, many of which could be applied to U.S. CRS policies and regulations. Nevertheless, OECD's recommendations were idealistic and fairly broad in nature and lacked details about implementation strategies concerning the earth observation component of the space industry.

While all of the aforementioned policy recommendations are sound and warranted, this dissertation offers alternate recommendations that it deems essential for advancing the interests and goals of the U.S. CRS industry and the USG alike and for creating a better environment in which U.S. CRS can be competitive in the global marketplace for CRS services and products. This section argues that commercial actors (i.e., U.S. CRS industry stakeholders) need to independently articulate and communicate the value of CRS to the public and private sectors. Further, the U.S. CRS industry needs to demonstrate the economic, scientific, and socio-political benefits of CRS activities to government actors and how such activity actually preserves and enhances national security and U.S. international relations. Essentially a PR campaign, the U.S. CRS industry tries to do this in various forums such as ACCRES, CRS symposiums and conferences, and on their corporate websites. Unfortunately, such enlightenment campaigns or educational efforts might not always reach key government decisionmakers, particularly in Congress and the White House. On the other hand, NOAA and key representatives of DOD (i.e., NGA), DOS, and DOI are actively involved in these information/educational venues.

USG support to U.S. CRS industry is often equated with promoting national security and foreign policy interests in various policy documents and regulations. Unfortunately, the symbiotic relationship between these two goals is not adequately spelled out in detail or made clear. Industry cannot simply rely on the DOC and forums sponsored by the USG or other private organizations to do this job. Although such forums function fairly well in filling knowledge voids and communicating industry's concerns to the government and the general public, they are not held often enough to provide a steady stream of information and knowledge essential for the CRS industry and the USG to stay abreast of international developments in civil and commercial earth observation technologies. Such forums also lack the frequency to help fine tune CRS policies and regulations on a more recurrent basis than current practices.

Since this dissertation focused on CRS-related knowledge voids and how they might negatively affect CRS policymaking and regulatory decisions, it seems appropriate to offer a mechanism for eliminating or at least reducing such problems in policymaking process. Obviously, the question is how could such and endeavor best be accomplished. One solution is for the USG to take the lead in filling CRS knowledge voids. Actually, NOAA has engaged in several projects to bridge knowledge gaps regarding licensing and regulation of U.S. CRS operations. In cooperation with other organizations, NOAA has funded several studies such as the aforementioned 2001 RAND report, as well as CRS industry forecast studies conducted by ASPRS and supported by NOAA and NASA.[69] In addition, NOAA holds licensing workshops and CRS symposiums to educate government, academia and the general public on CRS issues. Its first and second workshops were conducted in Washington, DC in September 2005 and January 2007, respectively. NOAA also holds ACCRES meetings that serve as a very effective knowledge void-filling forum for the CRS industry and its proponents and backers. Yet, despite these noble efforts, the educational process does not seem to reach significantly wide segments of the U.S. legislative and executive branches of government responsible for crafting CRS laws and policies. Unfortunately, more frequent studies, meetings, and conferences would probably be cost prohibitive and manpower intensive, given the fact that NOAA works within a fairly constrained budget and with finite resources. Furthermore, the NOAA staff (involved in CRS issues) is very busy with its day-to-day operations and duties and is probably unable to hold more frequent CRS knowledge-gap-spanning events.

Since the USG is doing its best to educate CRS stakeholders about CRS issues, the U.S. CRS industry should also devote more of its time, resources, and human capital to knowledge void-filling efforts. However, CRS satellite operators and value added firms are also busy running their CRS businesses, marketing their products and services, and dealing with a wide array of domestic international partners and customers. This makes it unlikely that the CRS industry will be able to go beyond its usual contacts with government officials to educate them about their business challenges and CRS policy concerns.

Another factor to consider is that the CRS industry is, according to some CRS observers, somewhat complacent about its comfortable position of being reliant upon the U.S. and foreign defense sectors for the bulk of its imagery sales revenues. Although it has attempted to expand its markets, the U.S. CRS industry has lacked a strong incentive to launch significant outreach and educational/promotional programs to dramatically expand those markets. Instead, the U.S. CRS industry has become highly dependent upon lucrative USG funding of its satellite operations through contracts such as ClearView and NextView (and hopefully follow-on contracts). Fortunately, the CRS industry is now actively recruiting persons with remote sensing and marketing expertise to help expand its market for imagery sales and applications.[70]

Given the extent of USG and industry efforts to fill CRS knowledge voids, this dissertation proposes that a separate entity be formed that would serve as an honest broker and proponent of the USG and the CRS industry alike. It would consist of an organization or institute that engages in significant research and outreach programs, which are completely focused on CRS policies, regulations, and competitiveness issues. The organization would almost function like a business, generating sufficient income through various means (explained below) to conduct CRS knowledge gap-filling studies and educational programs. In addition to filling knowledge voids, a key objective of the proposed organization would be to reverse engineer (i.e., find the source of and analyze) faulty knowledge claims concerning CRS issues. To support itself, the organization would derive income from three sources: Government funding and/or grants, industry contributions (should industry be convinced that it is in their best interests to help a program that ultimately supports it), and from the general business community and/or the general public by converting the organization's ideas and recommendations into profit making ventures. Income generating activities could also include research contracts with NOAA, reporting on the proceedings of CRS conferences, brainstorming and marketing (to value-added companies) novel means for using CRS imagery,[71] and publishing a CRS journal with paid advertisements. Although ASPRS already publishes a remote sensing and photogrammetric journal, it is geared more toward the technical aspects of remote sensing and image interpretation vs. the policy and marketing aspects of the field. The proposed name of the proposed organization is the Center for Commercial Remote Sensing Studies or C^2RS^2.

C^2RS^2 would conduct outreach activities to identify and establish relations with key government policymakers and decisionmakers who can influence the growth of U.S. CRS and keep it highly competitive in the growing international market for commercial earth observation data and products. It would then provide CRS information to these key decisionmakers concerning the opportunities and value of CRS and how it contributes to economic growth and national security. C^2RS^2 would essentially be a hybrid (academic/business) organization. Mixing traditional academic research with business and profit making motivations, C^2RS^2 would essentially conduct an enlightenment campaign, similar to a lobbying or advocacy group. Already one technology/analytical services company has expressed interest in sponsoring or supporting C^2RS^2-like activities but its identity is withheld for proprietary reasons.

Currently, there are several existing organizations that perform similar types of activities, but none of them deal solely with U.S. CRS issues. Such organizations consist of but are not limited to organizations such as RAND, ASPRS, the Space Enterprise Institute, the Aerospace Corp., and the Space Policy Institute of The George Washington University. Although numerous academic institutions specialize in CRS issues, much of their focus is on the technological and applications aspects of CRS and they also include civil remote sensing (not just the CRS). Virginia Tech, for example, has the Office of Geographical Information Systems and Remote Sensing (OGIS), which focuses on research and outreach activities concerning the scientific, technical, and application aspects of GIS and remote sensing, but (similar to ASPRS) not on CRS policy issues.[72] Another space studies organization is the National Center for Remote Sensing, Air and Space Law at the University of Mississippi.[73] That center conducts superlative studies on U.S. and international laws and policies for civil and commercial remote sensing, as well as legal and policies regimes governing general air and space activities. Recently, it has set up a blog as a forum for discussing space law and policy issues.

What would set the C^2RS^2 apart from the aforementioned organizations are its proposed missions as shown below:

- Specifically, study foreign CRS space systems and related activities (space systems and capabilities, CRS policies, business and marketing strategies, etc).
- Study aerial remote sensing firms and activities and develop ideas on how to better integrate them into the business plans of the CRS industry.
- Conduct outreach programs to better inform Congress and the administration about the value and unique contributions of U.S. CRS to the U.S. economy, scientific research efforts, and national security.
- Engage in critical and out-of-the-box thinking exercises to develop suggestions and ideas for supporting the competitiveness of the U.S. in the global CRS arena.
- Review and study current U.S. laws, policies, and regulations related to CRS and recommend improvements thereto.
- Study ways to expand the utility of CRS and make it more popular among the business community and the general public.
- Study ways to use high-resolution imagery in ways that would benefit DOD, DOS, and the missions of other relevant USG entities.

- Hold monthly forums for all CRS stakeholders (government, industry, academia, etc.) to brainstorm ideas. This would consist of small groups of ten to twenty participants, not like large conferences that are administratively and logistically challenging and expensive. Such forums would not have to be in physical places; web platforms such as gotomeeting.com could enable virtual contacts and discussions on a very frequent basis.
- Establish a virtual idea-exchange forum such as a website or blog (which could be supported by advertising).
- Publish a monthly newsletter (supported by approved advertising).

It is recommended that the actors who form and operate such an organization be extensively grounded in the research aspects of CRS technology and policymaking. The main determinants in the success or failure of such a proposal would lie in the ability to fund such an undertaking and in its credibility as a neutral voice in its advocacy role (i.e., balancing the interests and goals of industry and government, alike). As previously mentioned, it is anticipated that the U.S. CRS industry might not be a major financial backer of the proposed C^2RS^2 organization, although industry would benefit from the organization's educational, outreach, and advocacy activities. This should keep C^2RS^2 fairly neutral in its policy recommendations to the USG.

To some extent, C^2RS^2 would be modeled after research and advocacy organizations such as the Center for Democracy and Technology (CDT), Institute for Global Environmental Strategies (IGES), Computer Research Association (CRA), ASPRES, and ISPRS, but on a much smaller scale at the outset. A characteristic that would distinguish it from ASPRS and ISPRS (currently the two largest organizations focusing directly on remote sensing, mapping, and photogrammetry topics and issues) is that it would specifically focus on U.S. CRS policy and competitiveness issues only. Not funded to any degree by industry (if at all), C^2RS^2 would mainly pay for itself through government-funded research contracts, private contributions, and newsletter/journal subscriptions and advertising.

Aside from its mission to eliminate or fill CRS-related knowledge voids due to the vastness and complexity of CRS issues, C^2RS^2 would advocate and inform USG policies by increasing the motivation of the USG and U.S. citizens to become more informed and educated about the benefits of CRS and how it potentially impacts their lives. Such an effort would create greater public awareness of the contributions of CRS to societal wellbeing and conveniences. GoogleEarth and Microsoft's Virtual Earth are two contemporary applications of CRS that are increasing this awareness. The challenge is to make such novelties more engrained in our everyday lifestyles. If more constituents became familiar with the usefulness of CRS and view such as an integral part of their lives (through what some have called the geospatial information revolution),[74] Congress and the administration would be motivated to learn more about CRS issues and applications.

Although there is always the risk of being perceived as a small technocratic think tank or research organization, the C^2RS^2 can avoid this stigma by being open to ideas from the general public and it would do so through its blogs and website that promote a spirit of democratic participation in generating studies aimed at reducing CRS knowledge voids. Of course, the center would have to be careful in not getting into a position where it would be financially obligated to idea submitters. In this case, the center should not profit on any input or ideas received from the general public and the latter should be told that such ideas would simply go towards improving CRS policies and practices for the overall good of the public and the nation. Obviously, to be proficient, the C^2RS^2 would have to be an expert at many of its chosen CRS fields (more so policy and foreign competitiveness than the science and technical aspects of CRS systems) and completely avoiding the label of a small technocracy might be impossible. Still, one of the overall goals and missions envisioned for this proposed entity would be to provide another voice to industry and government policymakers/regulators that, in part, draws on popular participation.

International Programs and How the C^2RS^2 Could Contribute to Them

To bolster the competitiveness of the U.S. CRS industry in the global marketplace for commercial imagery sales and reduce knowledge gaps concerning the utility of CRS in the broader earth observation arena, it has been recommended that the USG more fully integrate the capabilities of the U.S. CRS industry with the goals and projects of international remote sensing organizations. The two major actors on the international stage of remote sensing are the Committee on Earth Observation Satellites (CEOS) and the Group on Earth Observations (GEO). CEOS works toward coordinating international earth observation systems and activities to meet the common good of member states, with special attention paid to those in the developing world.[75] Information conduits from CEOS to the U.S. flow through USG agencies such as NASA, NOAA, and the USGS. As an intergovernmental group, GEO is developing strategies and policies for implementing the Global Environmental Observation Systems of Systems (GEOSS) program. An entire panel of the 2006 CRS symposium was devoted to GEOSS and how the observation systems support a wide array of scientific and socio-economic applications in the field of agriculture, weather and climatology, land and water management and how it can be used to respond to natural and human disasters. Unfortunately, the only way that the U.S. CRS industry can play a significant role in these international efforts in the near term is for the USG and other foreign governments or organization to help fund imagery sales from CRS systems to support the GEOSS effort.

As the U.S. becomes increasingly involved in these international forums and the U.S. CRS industry is able to contribute to their efforts at globalizing earth monitoring systems, Congress and executive branch policymakers will, out of necessity, become more informed about global CRS issues. A key approach of C^2RS^2 to inspiring Congress and key USG policymakers and agency managers to become more interested in CRS is to augment the existing plethora of written communications and discourse with audio-visual aids that creatively portray the exciting world of remote sensing. Already spearheading a similar outreach effort is an initiative called the Alliance for Earth Observations, brainchild of IGES of Arlington, VA. Formed in 2004, the Alliance's goal is to "facilitate participation by the private sector in U.S. and international planning for Earth observations," [76] particularly as it relates to GEOSS. C^2RS^2 would complement the Alliance's efforts to educate Congress and USG officials grappling with challenging CRS issues. In doing so, C^2RS^2 would coordinate its research and outreach activities with IGES so that it does not compete with or duplicate the efforts of the Alliance.

Suggestions for Future STS Research on CRS Policy

This section proposes STS topics that could be researched and reported on by STS scholars and/or by the proposed C^2RS^2. Results of such efforts would go far toward filling knowledge voids on CRS policy issues for USG policymakers/regulators and for the CRS industry, as well. Probably the most important STS topic that cries for research is the international dimension of civil and commercial remote sensing. This dissertation proposes that in-depth, multidisciplinary studies be conducted to more fully and adequately understand foreign civil and commercial remote sensing space systems and related government policies and business practices. Gabrynowicz has pointed out that this is an area that not even the CRS industry thoroughly understands.[77]

Disciplines such as engineering, science, history, politics, economics and other social sciences offer effective research tools and methodologies for conducting such studies. The value of such STS research lies in satisfying the needs of U.S. policymakers and other CRS license decisionmakers (i.e., DOD, DOS, IC, etc.) to understand the political and economic implications of CRS regulations for U.S. CRS firms that struggle to stay completive and attempt to maintain a marginal lead in the global arena of CRS. Although foreign civil and commercial remote sensing programs were introduced and discussed in the 2001 RAND/ASPRS book entitled *Commercial Observation Satellites*, it has now been almost six years since that publication and it would be useful to have it updated.

Another area that was neglected or not covered in the 2001 book on CRS was why numerous firms apply for CRS licenses and yet fail to develop and launch CRS satellite systems in a reasonable period of time (five years or less). Are policies and regulations at fault for their inability to succeed in the highly competitive geospatial arena of CRS, or are funding or other issues the main problems? As of February 2004, NOAA had issued twenty-one licenses for U.S. CRS satellites.[78] Of those twenty-one licensees, five firms (i.e., GDE Systems Imaging, Motorola, Boeing, CTA Corp., and RDL Space Corp.) have had their licenses cancelled. Taking just one of those firms, for example, Boeing received a license for its planned Resource21 satellite but postponed the project due to funding issues. Perhaps assuming NOAA's CRS licenses were indefinite, it was not until 2002 that Boeing, BAE Systems, Farmland Industries, and the Institute for Technology Development (ITD) announced that they would proceed with the Resource21 satellite project.[79] Struggling to get the program rolling, Resource21 (also the name of the joint venture) sought financial support from NASA but was rebuffed by the agency and failed to reach an agreement for provision of Landsat Data Continuity Mission (LDCM) imagery from a 10-meter resolution Resource12 satellite (aka Chronos-1). Reportedly, Resource21 contemplated lobbying Congress to force NASA into supporting the company's CRS efforts.[80]

In late 2003, Resource21 was shut down by its investors due to its lack of success in obtaining government funding or purchasing agreements for its CRS imagery data.[81] This case is a classic example of industry-government conflicts and how so-called "commercial" earth observation satellite ventures still need to heavily rely on USG patronage and especially political support from Congress. It also demonstrates how ambitious and lofty CRS policies (devoid of financial-support mechanisms) can generate unrealistic optimism among would-be CRS operators but do not go a long way toward fostering the creation and growth of a viable CRS industry (particularly in the 1990s and early 2000's). It was not until 2003, that the CRSSP changed that situation. Unfortunately, it was a little too late for Resource21.

Another area for STS research is taking the knowledge void theories advanced by this dissertation and applying them to other STS fields such as biotechnology and bioethics or the social implications of bioscience/biotechnology, public participation in S&T policies (also called public understanding of science or S&T – PUS/PUST), information and communications technology and its impact on societal norms and values, or other areas of S&T. Such research efforts might attempt to draw a link between faulty knowledge about a particular aspect of science or technology and how such knowledge gaps affect policies and regulations that seek to control and/or promote those activities.

Even in the domain of CRS policy (as addressed throughout this dissertation), research projects could fruitfully employ STS tools and methodologies to prove or disprove a connection (or cause and effect relationship) between knowledge voids and perception gaps leading to undesirable or counterproductive policymaking in the fields of S&T. Such studies could focus on the CRS user communities and how knowledge voids hamper their ability to utilize CRS imagery. Commenting on this aspect of CRS in 1998 (the year before the first U.S. high-resolution CRS satellite was placed into orbit), Adigun Ade Abiodu, speaking on the global scale of this issue, stated: "There is also a major knowledge gap between the providers of raw remote sensing data [i.e. the CRS companies or civil satellite operators which includes governments] and the user community, particularly those interested in the new high-level information."[82] Such knowledge gaps concerning the utility of CRS imagery can even extend to the esoteric jargon of the field. Not everyone, even among those in the small community of CRS policymakers, is aware of all the terminology associated with spacebased remote sensing activities. An example of this occurred during the March 10, 2006 ACCRES meeting when Gene Whitney of OSTP was presenting a briefing about an update to the Landsat mission. Noticing that one of the slides mentioned that the future Landsat satellite would support scientific research missions, an unidentified person in the audience asked Whitney why the slide omitted the term "operationally responsive and desirable?"[83] Whitney seemed perplexed by or unfamiliar with that term. However, he assured the questioner that all future Landsat system capabilities and services would be addressed by the forthcoming OSTP report due to be completed by the fall of 2006.[84] The technical-bureaucratic jargon "operationally responsive and desirable" simply means civil remote sensing imagery that can assist government organizations in meeting their "operational" missions and would be "desirable" to meet that goal.

Within the field of the philosophy or sociology of science and technology, future CRS-related research could also focus on issues such as human rights and privacy issues. Questions to be addressed might entail looking at how increasing observation satellite capabilities could be abused to threaten individual privacy. Could the technology be developed to a point where individual movements could be tracked? Of course, we are still a long way off from such a capability and even if achieved, it could prove to be cost prohibitive. Earth observation satellites can image areas and positions but not real-time movements of personnel and vehicles. In order to accomplish the latter function, low-earth-orbit satellite-imaging systems would need to hover (a current impossibility). Otherwise, such capability would have to come from more advanced, futuristic optics on geostationary satellites. Moreover, it is important to understand that one CRS image would not be enough to be useful; several images of the same person or vehicle would need to be taken or the technology would have to advance to the point where streaming-video imaging capabilities could be achieved. Yet, as other technologies have advanced, CRS could also move in that direction – creating privacy issues that could be studied well in advance of their advent. Such research could also focus on who would pay for such capabilities or services. This socio-political aspect of CRS would be a valuable research topic for those interested in human rights and privacy issues. Another area of potential interest for philosophers of science and technology would be issues related to questions as to whether or not CRS is going to be fully automated or cyborgized. Could or will military, civil or CRS systems become the ultimate prosthetic eyes in the sky, able to see anywhere, anytime, and anything or anybody?

A final CRS-related STS research topic (that would be fruitful) involves the history and social studies of S&T, such as looking at CRS regulatory organizations to determine who the actors are and how they are selected for their missions and whether they are the most appropriate organizations for their tasks. For example, CRS observers have commented on NOAA's role in the CRS arena and questioned the wisdom of the USG selecting it (actually DOC, which then delegated CRS licensing duties to NOAA) as the agency responsible for regulating the operations of CRS space systems.[85] Using STS models and theories on institutional roles in regulating technology, research could be conducted to determine if NOAA is the best place to lodge authority for licensing and controlling CRS activities (which are primarily oriented toward land imaging) when NOAA's original charter is oriented toward the seas and the atmosphere.

Many of the aforementioned areas would be of immense interest to the U.S. CRS industry and its USG regulators, who are eager to learn as much as they can about all the facets of CRS to do their jobs more effectively. Such studies should enable industry to better convey its interests and challenges to USG policymakers and USG agencies dealing with CRS licensing and operational control issues. STS seems to be a very effective interdisciplinary field within which to launch such academic endeavors.

Stepping aside from CRS for a moment, it is perhaps appropriate at this juncture to suggest a different technology with significant policy implications that could serve as the object of STS research using my knowledge void theories. Such a technology would be that of nanotechnology. While the technology has immense promise for mankind, it could very well be considered a dual-use technology (from super hard materials used in combat vehicles to nanoscale cyborg soldiers) or a technology that could potentially threaten mankind as self-replicating automatons (at least in the opinion of many nanotechnology observers). The current policy on technology starts with the Clinton's administration's FY 2001 National Nanotechnology Initiative (NNI). Later in 2003, Congress passed the "21st Century Nanotechnology Research and Development Act."[86] Knowledge voids concerning the impact of this current and futuristic technology on the world or plain fear of its implications for society likely contributed to the Act not supporting the nanoscale molecule- or atom-manipulation research that could have been funded by the USG. This has parallels to security fears engendered by high-resolution CRS satellite systems and how they can potentially be used by adversarial groups or nations. Realizing there could be knowledge gaps associated with nanotechnology, the Center for Responsible Nanotechnolgy (CRN) raised the following questions: "Do Congress and the administration know what they are funding under the widely misunderstood heading of "nanotechnology"? Do they realize the full implications of their uncertainty and their contradictions?"[87]

Perhaps the greatest knowledge void associated with nanotech policy is not knowing what other nations are doing or going to do in that area (similar to knowledge voids on foreign CRS systems and policies already discussed in this dissertation). If we are ultra conservative and take a go-slow approach based on not knowing all the ramifications of nanotechnology, we might be placing ourselves in a position of follower rather than global leader in this exciting and potentially beneficial field of S&T. At any rate, nanotechnology (like CRS) is a field in which STS researchers could apply the theory of knowledge gaps to analyze and critique nanotech policy issues. Already, a Virginia Tech STS student has produced an excellent study (thesis) that surveys the field of nanotechnology and calls for a policy review of that field.[88]

Conclusion

Since the enactment of the Land Remote Sensing Commercialization Act in 1984, USG policies and procedures for dealing with the growing technological phenomenon of earth observation have been constructed in a socio-political environment of policy conflicts, influenced in part by knowledge voids and perception gaps. Nevertheless, a series of legislative, policy and regulatory milestones have enabled the U.S. CRS industry to develop and move along a path toward viable and profitable earth observation activities. Such milestones have provided a MacKenzie-like window or framework through which to examine and understand the dynamics of the social construction of CRS. Although the Landsat privatization period was strewn with policy mishaps, it served as a learning experience (filling knowledge voids) to prompt the USG into crafting more effective CRS policies embodied in the 1992 Land Remote Sensing Policy Act and the 1994 Presidential Decision Directive (PDD-23), the latter of which was replaced by the 2003 Commercial Remote Sensing Space Policy.

Even with the issuance of those two landmark documents (Policy Act and PDD-23), conflicts emerged and intensified over how U.S. CRS should be regulated. Such conflicts between the U.S. national security community and proponents of relatively unfettered CRS operations gradually gave way to increasing collaboration and erosion of CRS-related policy conflicts, over time – likely due to narrowing of knowledge and perceptions gaps – and ultimately led to the most favorable CRS policy to date (i.e., 2003 CRSSP) and support mechanism in the form of NGA's ClearView and NextView programs.

This chapter has postulated that the aforementioned CRS knowledge voids are based on several factors such as individual and institutional goals, missions, interests, and cultures, etc. and that such voids have influenced divergent perspectives on the threats and benefits of U.S. CRS in a global context. These gaps are multidimensional in nature and can be divided into various thematic categories for analytical purposes. Moreover, the sheer complexity of CRS issues also contributes to CRS knowledge and perception gaps and thus to the difficulty in their eradication. Consequently, this chapter offered several recommended actions to narrow such knowledge and perception gaps to enable the U.S. CRS industry to continue along a path of success and effectively compete in the global marketplace of earth observation data and information. The establishment of a CRS research and advocacy organization (C^2RS^2) – existing outside of the USG and the CRS industry but supporting the interests of both stakeholders – would help fill knowledge voids and contribute to the growth of the CRS industry. Its merit is based on the organization offering policy recommendations that would benefit both the government and industry and the overarching interest of the United States in promoting and maintaining global leadership in CRS. Although the interests of industry and government are different, there is some common ground between them (both want the U.S. space industrial base to be a global leader and want to foster growth in that important sector of the U.S. economy).

Since this is an STS dissertation, this chapter offered suggestions for future research in the field of remote sensing technology within the STS academic tradition. Such work can contribute a significant amount of new knowledge on the social, political, and economic dimensions of CRS, particularly concepts on and insights into possible links between knowledge/perception gaps and CRS policymaking, which have heretofore been fairly scant in the existing literature on CRS. Finally, highlights of the major findings and recommendations discussed in this chapter are shown below in Figure 4.3 below.

FINDINGS AND RECOMMENDATIONS
FINDINGS (CONCLUSIONS) ➢ **Privatization Period** Highly Problematic (Factors: Immature Market, Foreign Competition {France, Russia}, Rush to Privatize a Valuable National Asset, Numerous Knowledge Void/Perception Gaps). ➢ **Transition Period** - Vast Improvement but Still Many KVs, Perception Gaps (PGs), and Policy Conflicts. National Security Concerns Still Dominant. ➢ USG-Industry Collaboration Increases. New Forums Established to Fill KVs/Narrow PGs (ACCRES, CRS Symposiums/Workshops, CRS Working Groups). Good Start. ➢ Forums Too Infrequent/Industry Still Struggling (True Commercialization Impeded by Over Reliance on USG Patronage). ➢ US Lead in CRS Rapidly Narrowing (Foreign Competition) – Trend May Continue. May Need to Seek International Cooperation. ➢ New Mechanism Needed to Fill KVs (i.e., KVs on Legal, Policy, Technical, Foreign CRS Programs).
RECOMMENDATIONS (COURSES OF ACTION) ➢ Recognize and Reduce CRS-related KVs/Policy PGs. ➢ Improve CRS Policy Regimes (Make More Industry- Friendly). ➢ Establish CRS Research Center (C2RS2) to Augment Existing Forums. ➢ Future STS Studies using CRS KV Theory. Could Inform CRS and other S&T Policy Issues..

Figure 4.3 – Summary of Research Findings and Recommendations

The key aspect of this an previous chapters is the contribution to the STS literature in the form of my knowledge void theory as applied to the politics and policy dimensions of U.S. CRS activities. Encouraging is the fact that the Satellite Division of NOAA has requested a briefing to ACCRES on the ideas and theories (knowledge voids and perception gaps) advanced by this dissertation. Hopefully such briefing will provide insights based on these ideas and theories that will reduce some of the knowledge voids surrounding the challenging policy issues for U.S. CRS. Still, there is a vast amount of new knowledge that needs to be developed and provided through future STS research on this topic and the proposed C^2RS^2 could serve a pivotal role in such an effort. In addition to filling CRS-related knowledge voids, it is hoped that this dissertation will serve as a catalyst for additional STS research on the very important issues of CRS in the global arena of science and technology.

Notes

1. See Donald T. Lauer, An Evaluation of National Policies Governing the United States Civilian Satellite Land Remote Sensing Program, Ph.D. dissertation (Santa Barbara, CA: University of California at Santa Barbara, 1990).

2. Ray A. Williamson, "Remote Sensing Policy and the Development of Commercial Remote Sensing," in John C. Baker, Kevin M. O'Connell, and Ray A. Williamson, eds. *Commercial Observation Satellites: At The Leading Edge of Global Transparency* (Santa Monica, CA and Bethesda, MD: RAND and the American Society for Photogrammetry and Remote Sensing, 2001), 37.

3. Roland S. Inlow, "National Security Considerations" Impact on Intelligence Sources and Methods," 1989, in Robert A. McDonald, ed., *Proceedings: Space Imagery and News Gathering for the 1990s: So What?* (Symposium on Foreign Policy and Remote Sensing at the University of Kentucky), (Bethesda, MD: American Society for Photogrammetry and Remote Sensing, 1991), 56.

4. Ibid, 62-63.

5. Ibid, 63.

6. Jack E. Thomas, "A Defense Department Perspective on National Security Considerations Relating to Media News Gathering by Space Imagery" (1989) in McDonald, 66.

7. George E. Brown, Jr. "Closing Talk: Congress, 'Mediasat,' and the Future of Remote Sensing," in McDonald, 75.

8. Ibid.

9. Ibid, 76.

10. Peter M. P. Norris, "Landsat Multispectral and Thematic Mapper Imagery–What Is Commercially Available Today and Planned for the Future" (1989) in McDonald, 22.

11. J. Laurent Scharff, "News Dissemination of Images From Remote-Sensing Imagery: First Amendment Standards for Judging National Security Risks" (1989) in McDonald, 54.

12. White House, "Foreign Access To Remote Sensing Space Capabilities (Fact Sheet)," March 10, 1994, 1.

13. Commercial Space Act of 1998 (P.L. 105-303), January 27, 1998, 112.

14. Term suggested by Justin M. Gilbert, graduate of George Mason University and current law student at Widener University, during a casual conversation on January 15, 2006 concerning the

rationale for vagueness in the language of USG policy documents and why Congress has CRS-related knowledge voids.

15. White House, "National Space Policy Review (Fact Sheet, NSPD-15)," June 23, 2002; http://www.ostp.gov/html/02_7_15_2.html, accessed November 10, 2006.

16. White House, "U.S. Commercial Remote Sensing Policy (Fact Sheet)," April 25, 2003, 2; http:////crsp.usgs.gov/pdgs/factsheet.pdf, accessed November 13, 2006. Although the fact sheet did not use the term 'space' the actually policy document included the term and was called the U.S. Commercial Remote Sensing Space Policy (CRSSP). Also see White House, "Fact Sheet: U.S. Commercial Remote Sensing Space Policy," http://www.whitehouse.gov/news/releases/2003/05/20030513-8.html, accessed November 13, 2006.

17. Ibid, 3.

18. Joe Francica, "Dissecting the New U.S. Commercial Remote Sensing Space Policy," *Directions Magazine* (May 27, 2003); http://www.directionsmag.com/editorials.php?article_id=367&trv=1, accessed September 2, 2006.

19. Department of Commerce, National Oceanic and Atmospheric Administration, Licensing of Private Land Remote-Sensing Space Systems; Interim Final Rule (15 CFR Part 960), *Federal Register*, Vol. 65, No. 147 (Washington, DC: U.S. Government Printing Office, July 31, 2000), 46822-046837.

20. Department of Commerce, National Oceanic and Atmospheric Administration, Licensing of Private Land Remote-Sensing Space Systems; Proposed Rule (15 CFR 960), *Federal Register*, Vol. 70, No. 97 (Washington, DC: U.S. Government Printing Office, May 20, 2005), 29380-29386.

21. Ibid.

22. Department of Commerce, National Oceanic and Atmospheric Administration, Licensing of Private Land Remote-Sensing Space Systems; Final Rule (15 CFR Part 960), *Federal Register*, Vol. 71, No. 79 (Washington, DC: U.S. Government Printing Office, April 25, 2006), 24473-24491.

23. Kevin O'Connell and Greg Hilgenberg, "U.S. Remote Sensing Programs and Policies," in Baker O'Connell, and Williamson, 147.

24. National Oceanic and Atmospheric Administration, (webpage on CRS licensees); http://www.licensing.noaa.gov/licensees.html, accessed October 14, 2006.

25. Ibid.

26. Kevin M. O'Connell, et. al. *U.S. Commercial Remote Sensing Satellite Industry: An Analysis of Risks* (Santa Monica, CA: RAND, 2001), 88.

27. Joanne Gabrynowicz, responding to interview in Bates, Jason, "Teaching the Legal Aspects of Space Activity, *Space News*, (Apr. 19, 2004); http://www.space.com/spacenews/archive04/joannearch_040504.html accessed on 11 September 2005.

28. R. James Woolsey, statement in U.S. House of Representatives, Committee on Science, Space, and Technology and Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, (Washington, DC: U.S. Government Printing Office), 24.

29. Keith R. Hall, statement in U.S. House of Representatives, Committee on Science, Space, and Technology and Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 55.

30. Robert L. Gallucci, statement in U.S. House of Representatives, Committee on Science, Space and Technology and permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 63.

31. Dan Glickman, comments in U.S. House of Representatives, Committee on Science, Space and Technology and permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 71.

32. James H. Frey, statement in U.S. House of Representatives, Committee on Science, Space and Technology and permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 106.

33. Gabrynowicz, *The Land Remote Sensing Laws and Policies of National Governments: A Global Survey* (University, MS: University of Mississippi Law School, National Center for Remote Sensing, Air, and Space Law, January 3, 2007; http://www.spacelaw.olemiss.edu/activitiesandevents/2007/RS%20Law%20Global%20Survey.pdf, accessed May 26, 2007.

34. Mathew O'Connell, quoted in Joanna Glasner, "Satellites Will See More, Faster," Wired News (March 17, 2006); http://www.wired.com/news/technology/1,70267-0.html, accessed November 15, 2006.

35. Ann M. Florini, "The Opening Skies: Third-Party Imaging Satellites and U.S. Security," *International Security* 13 (Fall 1988), 97.

36. Regina Hagen, "Stop Cassini Earth Flyby," August 11, 1988, http://www.astronautix.com/craft/usa.htm, accessed October 30, 2005. Also see Sven Grahn, "The US-A program (Radar Ocean Reconnaissance Satellites – RORSAT) and radio observations thereof;" http://www.svengrahn.pp.se/trackind/RORSAT/RORSAT.html, accessed October 30, 2005.

37. _____, “US-A,” http://ww2.astornautix.com, accessed October 20, 2005.

38. Not needing an onboard reactor, the U.S. operated the short-lived Seasat synthetic aperture radar (SAR) satellite in the 1980s, using power from solar panels and batteries. See _____, “Seasat;” http://www.astronautix.com/craft/seasat.htm, accessed November 15, 2006.

39. _____, “ RADARSAT-2;” http://directory.eoportal.org/pres_RADARSAT2.html, accessed November 15, 2006.

40. James Oberg, “Spying for Dummies: The National Security Implications of Commercial Space Imaging,” on Oberg’s website at: http://jamesoberg.com/articles/spy/, accessed May 28, 2006. Original article with a shorter title written by James Oberg, “Spying for Dummies,” *IEEE Spectrum*, Vol. 36, No. 11 (November 1999), 62-69. Oberg stated that a correction would be issued in the January 2000 edition of Spectrum.

41. Oberg [website version].

42. Allen Thompson, “Israeli spysat coverage, resolution,” (message posted on newsgroup sci.space.policy) (November 4, 1995); http://www.fas.org/military/programs/asat/at_950411.htm, accessed May 28, 2006. Since Ofeq-3 was a military satellite, its specifications were probably not well publicized. In 1995, Thomson conducted a highly technical study to determine various operational capabilities of Ofeq-3 and determined that its average spatial resolution probably placed it in the 1-meter class of observation satellites (a far cry from 5 meters).

43. Dror Marom, “Israel: Germany freezes support for ‘David’ joint satellite project,” (posting on German website Globes [online]) February 10, 2003; http://www.imra.org.il/story.php3?id=15757, accessed May 28, 2006. According to Marom, the satellite project began in 1995 when the Israel Space Agency signed an agreement with its German counterpart (DAR). The satellite was designed as a civilian system to produce imagery with a 5-meter resolution.”

44. Comments of Patricia Maloney as recorded by Ken Thompson during the Commercial Remote Sensing Satellite Symposium, 13-15 September 2006, Washington, DC.

45. Mark David Gabriele, “How Open Will the Skies Really Be?,” in Baker, O’Connell and Williamson, 456.

46. Kevin M. O’Connell, et. al., 60.

47. Ann M. Florini and Yaya Dehqanzada, “The Global Politics of Commercial Observation Satellites,” in Baker, O’Connell and Williamson, 444; citing as their sources the U.S. Department of Transportation, Federal Aviation Administration, “Commercial Space Transportation,” (Washington, DC: 1999); [authors’] personal communication with Jim Martin of Raytheon Systems, Arlington, VA on September 29, 1999; and [authors’] personal

communications with Clayton Mowry of the Satellite Industries Association on September 28, 1999.

48. J.D. Wilson, "So Where's the High-Resolution Satellite Imagery," *GIS World* (GeoBusiness Watch) (October 1988); http://www.geoplace.com/gw/1998/1098/1098bwtc.asp, accessed May 28, 2006.

49. Oberg.

50. Recent examples of studies commissioned by NOAA or ACCRES or contributed to by NOAA officials on the business, organizational, and institutional aspects of CRS activities include: William Stoney, "Foreign Land Imaging Satellite Programs," (briefing) in Advisory Committee for Commercial Remote Sensing (ACCRES), National Oceanic and Atmospheric Administration (NOAA), Meeting Summary [2nd Meeting], January 14, 2003; http://www.accres.noaa.gov/Draft-Meeting-Minutes.doc, accessed September 14, 2007; Charles Mondello, George Hepner, and Ray A. Williams, 10-Year Remote Sensing Industry Forecast: Phases I-III – Study Documentation, Bethesda, MD, American Society for Photogrammetery and Remote Sensing (ASPRS), January 2004 (also carried in *PE&*RS, Vol. 70, No. 1 (January 2004),7-58; Mondello, Hepner, and Williamson, 10-Year Remote Sensing Industry Forecast: Phase IV, Bethesda, MD: ASPRS, September 2006 (also carried in *PE&RS*, Vol. 72, No. 9 (September 2006), 987-1000; Global Marketing Insights, Inc., Survey and Analysis of Remote Sensing Market, Aerial and Spaceborne, September 2005; http://www.licensing.noaa.gov/Survey/Analysis,pdf, accessed September 9, 2007; and Michael Oborne, ed., *Space 2030: Tackling Society's Challenges* (Paris, France: Organisation for Economic Co-Operation and Development, 2005 (see particularly Chapter 5: "Framework Conditions: Institutional Aspects," 129-171).

51. For examples of how "cognitive rigidity" affects individuals and organizations, see David W. Robson, "Cognitive Rigidity; methods to overcome it," (undated paper); http://analysis.mitre.org/proceedings/Final_Papers_Files/40_Camera_Ready_Paper.pdf, accessed February 10, 2007.

52. Current subcommittees for space and satellite activities are the House Subcommittee on Space and Aeronautics and the Senate Subcommittee on Science and Space.

53. Mathew O'Connell, comments recorded by Ken Thompson during the Commercial Remote Sensing Satellite Symposium.

54. See Charles Perrow, *Normal Accidents: Living with High-Risk Technologies* (NY: Basic Books, Inc., 1984).

55. Ibid, 73.

56. See U.S. Congress, Office of Technology Assessment, *Space Policy and Applications* (Washington, DC: U.S. Government Printing Office, June 1982),

57. Ibid, 14.

58. U.S. Congress, Office of Technology, *Remote Sensing and the Private Sector: Issues for Discussion – Technical Memorandum (OTA-TM-ISC-20)* (Washington, DC: U.S. Government Printing Office, March 1984).

59. Ibid, 3.

60. Ibid.

61. See U.S. Congress, Office of Technology Assessment, *Civilian Satellite Remote Sensing: A Strategic Approach (OTA-ISS-607)* (Washington, DC: U.S. Government Printing Office, September 1994.

62. Ibid, 2.

63. Email correspondence from Janet Abbate, Associate Professor of STS (Virginia Tech) on September 5, 2007.

64. Kevin M. O'Connell, et. al., 93-95.

65. Mathew O'Connell, comments in Thompson, rapporteur, *Proceedings • Commercial Remote Sensing Satellite Symposium*, edited by Judith Carrodeguas, Dan Stillman, Ken Thompson, and Kay Weston (Washington, DC: Institute for Global Environmental Strategies, 2006), 22.

66. Michael Oborne, ed. *Space 2030: Tackling Society's Challenges* (Paris, France: Organization for Economic Co-Operation and Development (OECD), 2005), 205-271.

67. Ibid, 210.

68. Ibid.

69. See Charles Mondello, George F. Hepner, and Ray A. Williamson, 10-Year Industry Forecast: Phases I-III – Study Documentation, Bethesda, MD, American Society for Photogrammetry and Remote Sensing, January 2004. Also see, Mondello, Hepner, and Williamson, 10-Year Remote Sensing Industry Forecast: Phase IV – Study Documentation Bethesda, MD, American Society for Photogrammetery and Remote Sensing, September 2006. In addition, see Global Marketing Insights, Inc., "Survey and Analysis of Remote Sensing Market: Aerial and Spaceborne," September 2005; http://www.licensing.noaa.gov/Survey/Analysis,pdf, accessed September 9, 2007.

70. See GeoEye, "Employment Opportunities;" http://geoeye.com/corporate/jobs.htm, accessed February 10, 2007.

71. Many CRS observers have written about the need for the U.S. CRS industry to be creative and develop new market and innovative applications for its imagery data. For example, see O'Connell, et. al., 96-97. Also see Judith Carrodeguas and Dan Stillman, eds. Commercial Satellite Remote Sensing Symposium: Proceedings, "Improving the International Business Environment," Institute for Global Environmental Strategies, May 13-15, 2003, 37, 42; http://www.licensing.noaa.gov/SymposProceed-Mar9.pdf, accessed September 11, 2007. In addition, see _____, (untitled article); *Space News Business Report* (May 27, 20030: http://www.space.com/spacenews/archive03/editarch_052703.html, accessed January 16, 2007.

72. Office of Geographical Information Systems and Remote Sensing (OGIS), Virginia Polytechnic Institute and State University; http://ecs.lib.vt.edu/VT_OGIS/wwwmain.html, accessed November 19, 2006.

73. National Center for Remote Sensing, Air and Space Law, The University of Mississippi; http://www.spacelaw.olemiss.edu/, accessed November 19, 2006.

74. For an excellent article on the geospatial revolution, see Jack Dangermond, "GIS: Helping Manage Our World," *GIS Development*, Vol. 10, Issue 12 (December 26, 20050: http://www.gisdevelopment.net/magazine/years/2005/dec26_1.htm, accessed January 20, 2007. Also see Sally Matthews, "Worldwide Trends in Geographic Information Systems," Access America (USG website) (no date); http://govinfo.libary.unt.edu/accessamerica/dogs/gis.html, accessed January 20, 2007. Even the "18th Annual GIS in the Rockies Conference" (September 21-23, 2005) had as its theme, "The Geospatial Revolution: A Whole New World;' see _____, 18th Annual GIS in the Rockies Conference, September 21-23, 2005 (press release by BIS in the Rockies.org), *Directions Magazine* (September 6, 2005); http://www.directionsmag.com/press.releases/?duty=Show&id=12452, accessed January 20, 2007.

75. _____, "CEOS Activities and Initiatives; http://www.ceos.org/pages/act.html, accessed January 20, 2007.

76. Dan Stillman, "A Growing Alliance: The Alliance for Earth Observations," *Observe* (IGES newsletter), Vol. 1, No. 2 (August 2006), 4.

77. Gabrynowicz, videotaped lectures for course entitled Space Studies 575, Grand Rapids, ND: University of North Dakota, Spring 2000.

78. Department of Commerce, National Oceanic and Atmospheric Administration, National Environment Satellite, Data, and Information Service (NESDIS), "NOAA Licensees: Licenses of Commercial Remote Sensing Satellite Systems;" http://www.licensing.noaa.gov/licensees.html, accessed November 26, 2006. As of November 19, 2007, NOAA had cancelled several inactive licenses and added others and the list now shows a total of 17 licenses.

79. Boeing Corp., (news release); http://www.boeing.com/news/releases/2001/q3/nr_010802t.html, accessed November 10, 2006.

The Resource21 project was envisioned to support agribusiness and the Landsat data Continuity Mission (LDCM).

80. Brian Berger and Jason Bates, “Resource21 Lobbies for NASA to reconsider Landsat Bid,” *Space News* (November 11, 2003); http://www.space.com/spacenews/archive03/landsatarch_111103.html, accessed November 10, 2006.

81. Jason Bates and Brian Berger, “Failure to Capture Landsat Contract Dooms Resource 21,” *Space News* (March 15, 2004); http://www.space.com/spacenews/archive04/landsatarch_031504.html, accessed November 10, 2006. Also see Adena Schutzberg, “Resource21 Aims High, Falls Hard,” *Earth Observation Magazine* (online version), (April-May 2004); http://www.eomonline.com/Common/Archives/2004aprmay/04aprmay_resource21.html, accessed November 10, 2006

82. Adigun Ade Abiodun, “Remote sensing in the information age,” *Space Policy*, Vol. 14, No. 4 (November 1998), 229.

83. Gene Whitney, comments and repose to a question during the public session of ACCRES meeting held in Washington, DC on March 10, 2006.

84. Ibid.

85. Kevin M. O’Connell, et. al, 77. Also see Williamson, 43-44.

86. 21st Century Nanotechnology Research and Development Act (PL 108-153), December 3, 2003. Also see _____, “U.S. Nanotechnology Policy – Missing the Point,” Center for Responsible Nanotechnology (no date); http://www.crnano.org/us-policy.htm, accessed September 3, 2007.

87. Ibid.

88. Richard Smith, “A Policy Framework for Developing a National Nanotechnology Program” (master’s thesis), Blacksburg, VA, 1998.

Bibliography

Abbate, Janet, email dated September 5, 2007.

Adams, Dewy, Dominick Bruno, Piyush Shah and Brian Keller, "Precision Control, Knowledge and Orbit Determination on a Small Spacecraft Bus; The OrbView-4 Attitude Control System," Report No. SSC98-IX-3 from the Proceedings of the 12th AIAA/USU Conference on Small Satellites , Logan, UT: Utah State University, August 1998), 3.

Advisory Committee on Commercial Remote Sensing (ACCRES), National Oceanic and Atmospheric Administration (NOAA). "U.S. Department of Commerce Charter of the Advisory Committee on Commercial Remote Sensing, May 3, 2004;" http://www.accres.noaa.gov/ACCRESCharter5504.pdf, accessed June 17, 2006.

Abiodun, Adigun Ade. "Remote sensing in the information age," *Space Policy*, Vol. 14, No. 4, November 1998, 229-238.

_____, "About GEO; http://www.earthobservations.org/about/about_GEO.html, accessed January 19, 2007.

Aerospace Industries Association, "Policy Reforms to Support the U.S. Satellite Remote Sensing Industry Base," (report posted on July 1, 2004); http://www.aia-aeropsace.org/pdf/policy_reforms_to_support_the_us.pdf, accessed January 18, 2007.

Amato, Ivan. "God's Eyes for Sale," *Technology Review*, Vol. 102, No. 2 (March-April 1999), 36-41.

Andrieu, Michel, et. al. *Space 2030: Tackling Society's Challenges*, Paris, France: OECD, 2005.

______, "Arirang-2 Satellite to Launch This Year," *KBS Global*, May 31, 2005; http://english.kbs.co.kr/news/newsview_sub.php?menu=6&key=2005053111, accessed October 10, 2005.

_____, "ASPRS Industry News," *Photogrammetric Engineering and Remote Sensing* (*PE&RS*), Vol. 70, No. 12 (December 2004), 1342-1345.

_____, *Astropolitics: The International Journal of Space Politics and Policy*, journal published by Taylor and Francis, Inc., Philadelphia, PA (cited herein as a useful source for topics on astropolitics).

Baker, D. James, statement in U.S. House of Representatives; Committee on Science, Space, and Technology and Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 38.

Baker, John C. “Global Competition Creates Cooperative Opportunities,” *Imaging Notes*, (January-February 2002; http://www.imagingnotes.com/janbeb02/global.htm, accessed August 29, 2005.

Baker, John C. “Global Transparency: Whither Shutter Controls,” *Imaging Notes*, Vol. 18, No. 1, Winter 2003; http://www.imagingnotes.com/winter03/global.htm, accessed October 8, 2005.

Baker, John C. “New Users and Established Experts: Bridging the Knowledge Gap in Interpreting Commercial Satellite Imagery,” in Baker, O’Connell, and Williamson, 533-557.

Baker, John C. and Dana J. Johnson, “Security Implications of Commercial Satellite Imagery,” in Baker, O’Connell, and Williamson, 101-133.

Baker, John C., Kevin M. O’Connell, and Ray A. Williamson. *Commercial Observation Satellites: At The Leading Edge of Global Transparency*, Santa Monica, CA: RAND and Bethesda, MD: ASPRS, 2001.

Baker, John C. Baker, Ray A. Williamson and Kevin M. O’Connell, “Introduction,” in Baker, O’Connell and Williamson, 1-11.

Baker, Wim. The Indian Remote Sensing satellites,” *EARSeL Newsletter*, June 1998; http://www.itc.nl/~bakker/earsel/9806b.html, accessed June 3, 2006.

Barnes, Scottie. “NGA Awards NextView Second Vendor Agreement,” *Geospatial Solutions* , October 1, 2004; http://www.geospatial-online.com/geospatialsolutions/articleDetail.jsp?id=125948, accessed June 11, 2006.

Barnes, Scottie. “Open Access,” *Geospatial Solutions*, Vol. 14, No. 10, October 1, 2004, 10.

Bartlett, David, letter dated February 8, 1994 to Congressman George E. Brown, Jr. and Dan Glickman, U.S. Congress, Committee on Science, Space, and Technology and the Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 133-135.

Bates, Jason. “Orbimage Reaches Deal to Emerge From Bankruptcy,” *Space News*, February 3, 2003; http://www.space.com/spacenews/archive03/orbimagearch_020303.htm, accessed September 1, 2007.

Bates, Jason. “NIMA Locks Up Ikonos Time Over Afghanistan,” October 15, 2001; http://www.space.com/spacenews/nima_101501.html, accessed July 29, 2006.

Bates, Jason. “Plan Would Put the USGS In Charge of Buying Commercial Imagery,” *Space News*, January 5, 2004; http://www.space.com/spacenews/archive03/usgsarch_122303.html, accessed February 14, 2006.

Bates, Jason and Brian Berger. "Failure to Capture Landsat Contract Dooms Resource 21," *Space News*, March 15, 2004; http://www.space.com/spacenews/archive04/landsatarch_031504.html, accessed November 10, 2006.

Beck, David, et. al., "Industry Studies 2000: Space" (ICAF Industry Studies, 2000 Report on Space); http://www.ndu.edu/icaf/industry/2000/space/space.htm#_edn48, accessed June 18, 2006.

Belligan, Michael/ "Mixed Signals: A History of the Landsat Program and U.S. Commercial Remote Sensing Industry," (unpublished paper), Fall 2004; http://www.msu.edu/~belligal/GEO801_LANDSAT.htm, accessed May 27, 2006.

Benditt, John. "Nowhere to Hide," *Technology Review*, Vol. 102, No. 2, March-April 1999, 8.

Berger, Brian and Jason Bates, "Resource21 Lobbies for NASA to reconsider Landsat Bid," *Space News*, November 11, 2003; http://www.space.com/spacenews/archive03/landsatarch_111103.html, accessed November 10, 2006.

Bijker, Weibe E., Thomas P. Hughes and Trevor J. Pinch, eds., *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, Cambridge, MA: The MIT Press, 1999.

Bijker, Weibe E., "The Social Construction of Bakelite: Toward a Theory of Invention," in Bijker, Hughes, and Pinch, 159-187.

Bilbray, James, statement in U.S. House of Representatives; Committee on Science, Space, and Technology and Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 72.

Bjorgo, Einar. "Supporting Humanitarian Relief Operations," in Baker, O'Connell, and Williamson, 403-427.

Black, J. Todd. "Commercial Satellites: Future Threats or Allies?," *Naval War College Review*, Vol. LII, No. 1, Winter 1999, 99-114.

Black, J. Todd. "Commercial Satellites: Future Threats or Allies?," *Naval War College Review* (Winter 1999); http://www.nwc.navy.mil/press/Review/1999/winter/art5~w99.htm, accessed September 18, 2005.

Boeing Corp, (news release); http://www.boeing.com/news/releases/2001/q3/nr_010802t.html, accessed November 10, 2006.

Bourbonniere, Michel and Louis Haeck. “Canada’s Remote Sensing Program and Policies,” in Baker, O’Connell, and Williamson, 263-294.

Brannon, David, statement in U.S. House of Representatives, Subcommittee on Basic Research. “Using Commercial Data Sources in the Earth Science Enterprise,” Washington, September 28, 1998; http://www.hq.nasa.gov/congress/brannon9-28.html, accessed April 10, 2006.

Brender, Mark. “Testimony of Mark Brender, Chairman, Radio-Television News Directors Association Remote Sensing Task Force before the Subcommittee on Space and Aeronautics, U.S. House of Representatives, Committee on Science,” July 24, 1996; http://www.house.gov/science/mark_brender.htm, accessed August 24, 2005.

Brown, George, statement in U.S House of Representatives, Committee on Science, Space, and Technology and House Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post Cold War Era*, 1.

Brown, George, E., Jr. “Closing Talk: Congress, ‘Mediasat,’ and the Future of Remote Sensing,” in McDonald, 73-79.

Caceres, Marco. “Focus sharpens for imaging satellite imagery,” *Aerospace America*, Vol. 38, No. 9, September 2000, 16-18.

Calhoun-Senghor, Keith, statement in U.S. House of Representatives, Committee on Science, Subcommittee on Space and Aeronautics. “The Commercial Space Act of 1997, Part I.

Carrodeguas, Judith and Dan Stillman, eds. Commercial Satellite Remote Sensing Symposium: Proceedings, “Improving the International Business Environment,” Institute for Global Environmental Strategies, May 13-15, 2003; http://www.licensing.noaa.gov/SymposProceed-Mar9.pdf, accessed September 11, 2007.

Caterinicchia, Dan. “NIMA seeks ‘Clearview’ of world,” January 17, 2003; http://www.govhealthit.com/article78527, accessed July 15, 2006.

Cecere, Tom. “Commercial Remote Sensing Space Policy (CRSSP) and Opportunities For Collaboration” (presentation to the EPA 2005 Science Forum: Collaborative Science for Environmental Solutions held in Washington, DC on May 16-18, 2003); http://www.epa.gov/ord/scienceforum/2005/pdfs/presentations/7-Cecere_Tom%20revised.pdf, accessed April 22, 2006.

Center for Nonproliferation Studies, "Israel: Military Programs;" http://cns.miis.edu/research/space/israel/mil.htm, accessed 27 May 2006.

_____, "CEOS Activities and Initiatives; http://www.ceos.org/pages/act.html, accessed January 20, 2007.

Clark, Adele. "A Social Worlds Adventure," in Susan Cozzens and Thomas Gieryn, eds., *Theories of Science in Society*, Bloomington, Indiana: Indiana University Press, 1990, 15-42.

Clarke, Dana G. "Access Control of Remote Sensing Satellites," in Keeley and Huebert, 171-178.

Code of Federal Regulations, Title 22, Part 102 (The United States Munitions List); http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c= ecfr&sid=03a931bd08388c 73093352157a54df60&tpl=/ecfrbrowse/Title22/22cfr121_main_02.tpl, accessed June 18, 2006.

Combest, Larry, statement in U.S. Congress, Joint Hearing before the Committee on Science, Space, and Technology and the House Permanent Select Committee on Intelligence. *Commercial Remote Sensing in the Post-Cold War Era*, 20.

Commercial Space Act of 1998 (P.L. 105-303), January 27, 1998; Section 107 (in Appendix D of this dissertation) available at NASA website: http://geo.arc.nasa.gov/sge/landsat/sec107.html, accessed November 28, 2006.

_____, "Contracts: National Imagery and Mapping Agency –Correction," (press release No. 026-03), Washington, DC: U.S. Department of Defense, January 17, 2003; http://www.defenselink.mil/contracts/2003/c01172003_ct026-03.html, accessed June 25, 2006.

_____, "Contracts: National Geospatial-Intelligence Agency" (press release 970-04), Washington: DOD (Office of the Assistant Secretary of Defense (Public Affairs)), September 30, 2004; http://www.defenselink.mil/contracts/2004/ct20040930.html, accessed April 23, 2006.

Copple, John R, letter to Senator Bill Frist, U.S. Senate, Senate Commerce Subcommittee on Science, Technology, and Space (hearings); http://commerce.senate.gov/hearings/35cop.pdf, accessed October 29, 2005.

Corn, David. Their Spy in the Sky," *The Nation*, November 26, 2001; http://www.thenation.com/DOC/20011126/corn, accessed 8 October 2005.

Cramer, Robert E., statement in U.S. House of Representatives, Subcommittee on Space and Aeronautics, Committee on Science, *Hearings on the Commercial Space Act of*

1997, 4.

Curlander, John, comments in Carrodeguas Stillman, 41-42.

Curtis, Anthony R. *Space Satellite Handbook*, 3rd Ed., Houston, TX: Gulf Publishing Co., 1994.

Dailey, Brian and Edward McGaffigan, "US Commercial Satellite Export Control Policy: A Debate," in Henry Sokolski, ed., *Fighting Proliferation: New Concerns for the Nineties*, Maxwell AFB, AL: Air University Press, Sept. 1996, 169-180.

Dangermond, Jack. "GIS: Helping Manage Our World," *GIS Development*, Vol. 10, Issue 12, December 26, 2005; http://www.gisdevelopment.net/magazine/years/2005/dec26_1.htm, accessed January 20, 2007.

Davis, Richard. "The Foreign Policymaking Role of Congress in the 1990s: Remote Sensing Technology and the Future of Congressional Power," *Congress and the Presidency: A Journal of Capital Studies*, Vol. 19, No. 2, Autumn 1992, 175-92.

Damilano, Patrice. "Pleiades High Resolution Satellite: a Solution for Military and Civilian Needs in Metric-Class Optical Observations," SSCO1-I-5; paper presented August 13, 2001 at the 15th Annual AIAA/Utah State University Conference on Small Satellites, 1-2; http://www.aria.seas.ustl.edu/SC01/papers/1-5.pdf, accessed October 10, 2000.

Dehqanzada, Yahya and Ann Florini, *Secrets for Sale: How Commercial Satellite Imagery Will Change the World* , Washington, DC: Carnegie Endowment for International Peace, 2000.

Department of Commerce, National Oceanic and Atmospheric Administration, Licensing of Private Land Remote-Sensing Space Systems; Final Rule (15 CFR Part 960), *Federal Register*, Vol. 71, No. 79, Washington, DC: U.S. Government Printing Office, April 25, 2006, 24473-24491.

Department of Commerce, National Oceanic and Atmospheric Administration, "Licensing of Private Land Remote Sensing Space Systems; Interim First Rule (15 CFR Part 960)," *Federal Register*, Part IV, Vol. 65, No. 147, July 31, 2000, 46822-46837.

Department of Commerce, National Oceanic and Atmospheric Administration, Licensing of Private Land Remote-Sensing Space Systems; Interim Final Rule (15 CFR Part 960), *Federal Register*, Vol. 65, No. 147, Washington, DC: U.S. Government Printing Office, July 31, 2000, 46822-046837.

Department of Commerce, National Oceanic and Atmospheric Administration, Licensing of Private Land Remote-Sensing Space Systems; Proposed Rule (15 CFR 960), *Federal Register*, Vol. 70, No. 97, Washington, DC: U.S. Government Printing Office, May 20, 2005, 29380-29386.

Department of Commerce, National Oceanic and Atmospheric Administration, National Environment Satellite, Data, and Information Service (NESDIS). "NOAA Licensees: Licenses of Commercial Remote Sensing Satellite Systems;" http://www.licensing.noaa.gov/licensees.html, accessed November 26, 2006.

Department of Commerce, Office of Space Commercialization, "General Policy Issues;" http://www.nesdis.noaa.gov/space/general/, accessed June 11, 2006.

de Selding, Peter B. "Weight Gain Could Boost Cost of Cosmo-Skymed Craft," *Space News*, February 2, 2004; http://www.space.com/spacenews/archive04/cosmoarch_020204.html, accessed October 10, 2005.

Devarics, Charles. "Private eyes: Commercial satellite imagery in demand for intelligence and disaster recover," *C4ISR*, November 28, 2005; http://www.isrjournal.com/story.php?F=1130593, accessed April 23, 2006.

Dicks, Norman D., statement in U.S. House of Representatives; Committee on Science, Space, and Technology and Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 38.

_____, "Digital Globe Applauds Remote Sensing policy Issued by White House," (press release), Longmont, CO: DigitalGlobe, May 13, 2003; http://media.digitalglobe.com/index.php?s=press_release_popup&item=25, accessed June 11, 2006.

_____, "DigitalGlobe Awarded $500 Million NextView Contract from NIMA," *Space Daily*, October 1, 2003; http://www.spacedaily.com/news/eo-03zzza.html, accessed July 15, 2006.

DigitalGlobe. "DigitalGlobe Awarded in Excess of $500 Million NextView Contract;" (press release), September 30, 2003; http://media.digitalglobe.com/index.php?s=press_release_popup&item=11, accessed June 11, 2006.

DigitalGlobe. "History [of DigitalGlobe];" http://www.digitalglobe.com/about/history.shtml, accessed March 26, 2006.

DigitalGlobe, "2002 Archives," May 30, 2002; http://media.digitalglobe.com/index.php?s=press_releases&year=2002, accessed May 27, 2002.

Dinerman, Taylor. "Intelligence Failure at the Networks," *The Space Review*, April 2004; http://www.thespacereview.com/article/191/1, accessed August 21, 2005.

Dobb, Joe, comments cited by Ben Iannotta, "Setting the rules for remote sensing," *Aerospace America*, Vol. 37, No. 4 (April 1999), 34-48.

Dvorkin, Corey Michael. "Two Steps Back: The Uncertain Promise for the Strategic Use of Commercial Satellite Imagery," in Kelley and Huebert, 143-170.

_____, Earth Observation Resources; http://directory.eoportal.org/res_p1_Earthobservation.html, accessed May 18, 2007.

Earth Satellite Company and Abt Associates Inc. A Study to Examine the Mechanisms to Carry Out the Transfer of Civil Remote Sensing Systems to the Private Sector, March 28, 1983, DOC Contract No. NA-93-SAC-066.

ECON, Inc., Commercialization of the Land Remote Sensing Satellite System (Landsat), April 1, 1983, DOC Contract No. NA-93-SAC-00658.

_____, 18th Annual GIS in the Rockies Conference, September 21-23, 2005 (press release by BIS in the Rockies.org), *Directions Magazine*, September 6, 2005; http://www.directionsmag.com/press.releases/?duty=Show&id=12452, accessed January 20, 2007.

Elam, Mark. "Spyglass On The World: The Culture and Politics of Remote Sensing," draft paper presented at the Cultural Politics of Technology Workshop, Trondeim, Norway, Centre for Technology and Society, Norwegian University of Technology and Science, June 15-16, 1998; http://www.ntnu.no/sts/content/Papers/Spyglass.html, accessed May 13, 2005.

eoPortal; http://directory.eoportal.org, accessed October 28, 2007.

_____,"EROS-A (Earth Remote Observation System-A)," eoPortal (European Space Agency/ESRIN in Frascati, Italy); http://directory.eoportal.org/pres_EROSEarthRemoteObservationSatellite.html, accessed April 2, 2006.

_____, "EROS-B program:' http://www.imagesatintl.com/default.asp?catid={967F2328-D51E-4AC9-929E-FF6FD434B414}, accessed on August 27, 2005.

Eshoo, Anna C., comments in U.S. House of Representatives; Committee on Science, Space, and Technology and Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 80.

Federation of American Scientists. "KH-1 CORONA;" http://www.fas.org/spp/military/program/imint/kh-1.htm, accessed May 27 2006.

Ferster, Warren, comments in Judith Carrodeguas and Dan Stillman, eds., "Commercial Satellite Remote Sensing Symposium: Improving the International Business Environment" (Proceedings), Washington: Institute for Global Environmental Strategies (IGES), 35; http://www.strategies.org/symposium/SymposProcedings.pdf, accessed February 12, 2006.

15 United States Code 82, Land Remote Sensing Policy, Subchapter II, Licensing of Private Remote Sensing Space Systems, Sec. 5621, General Licensing Authority; http://geo.arc.nasa.gov/sge/landsat/15USCch82.html, accessed April 23, 2006.

Fillion, Roger. "Orbit of change for satellite firms. Pared-down industry gets set to launch new-ear technology," *Rocky Mountain News*, January 9, 2006; http://www.rockymountainnews.com/drmn/tech/article/0,2777,DRMN_23910_4373447,00.html, accessed March 26, 2006.

Fillion, Roger. "Shakeout: Too many companies for too few deals jolt satellite-imaging industry," *Rocky Mountain News*, August 8, 2005; http://www.globalsecurity.org/org/news/2005/050808-satellite-imagery.htm, accessed March 26, 2006.

Florini, Ann and Yahya Dequanzada ,"Commercial Satellite Imagery Comes of Age," *Issues in Science and Technology online*, Fall 1999;" http://www.issues.org/16.1/florinia.htm, accessed June 13, 2004.

Florini, Ann and Yahya Dehqanzada, *No More Secrets? Policy Implications of Commercial Remote Sensing Satellites*, Washington, DC: Carnegie Endowment for International Peace, 2000. (Note: Various versions of same or similar paper listed below)

Florini, Ann M. and Yahya A. Dehqanzada, "No More Secrets? Policy Implications of Commercial Remote Sensing Satellites," Global Policy Program: Project on Transparency. Working Paper No. 1, July 1999; http://www.ceip.org/files/projects/tcs/remotesensingconf/NoMoreSecrets1.htm, accessed November 27, 2005.

Florini, Ann M. and Yahya A. Dehqanzada, "No More Secrets? Policy Implications of Commercial Remote Sensing Satellites," Carnegie Paper No. 1, Washington, DC, July 1, 1999); http://www.carnegieendowment.org/publications/index.cfm?fa=print&id=150, accessed October 28, 2007.

Florini, Ann M. Florini and Yahya A. Dehqanzada, "No More Secrets? Policy Implications of Commercial Remote Sensing Satellites," (working paper No. 1 prepared for a conference by the same title), July 1999; http://www.ceip.org/programs/governance/remotesensingconf/NoMoreSecrets1.htm, accessed June 13, 2004.

Florini, Ann and Yahya Dehqanzada, "The Global Politics of Commercial Observation Satellites," in Baker, O'Connell, and Williamson, 433-448.

Florini, Ann. "The Opening Skies: Third-Party Imaging Satellites and U.S. Security," *International Security*, Vol. 13, No. 2, Autumn, 1988, 91-123.

_____, "Foreign competition may be the only way to lift U.S. regs," *EO Reports*, No. 185, May 1999; http://www.spie.org/Web/oer/may/may99/cover1.html, accessed February 9, 2006.

_____, "403.Transfer of Certain Remote Sensing Satellites from the U.S. Munitions List to the CCL" (Washington, DC: U.S. Department of Commerce); http://ciir.cs.umass.edu/cgi-bin/ua/web_fetch_doc?dataset=ua&db=agendaApril1996&doc_id=x0694-AB09&query=and, … accessed June 18, 2006.

Foster, Deborah. "The Indian Space Program, in Baker, O'Connell, and Williamson, 247-261.

Francica, Joe. "Dissecting the New U.S. Commercial Remote Sensing Space Policy," *Directions Magazine*, May 27, 2003; http://www.directionsmag.com/editorials.php?article_id=367&trv=1, accessed September 2, 2006.

Frey, James H. statement in U.S. House of Representatives, Committee on Science, Space and Technology and Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 106, 119.

Frey, James H., Terry A. Straeter, and David W. Thompson. "Testimony to the Joint Hearing of the House Permanent Select Committee On Intelligence and the House Committee On Science and Technology" (Litton Itek Optical Systems, Orbital Sciences Corporation, and GDE Systems Inc., February 9, 1994 in U.S. House of Representatives, Committee on Science, Space, and Technology and the House Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era,* 9.

Fritz, Lawrence W. "The Era of Commercial Earth Observation Satellites," *Photogrammetric Engineering and Remote Sensing*, Vol. 62, No. 1, January 1996, 39-45.

Fritz, Lawrence W. "High Resolution Commercial Remote Sensing Satellites and Spatial Information Systems," *IRSPS Highlights*, Vol. 4, No. 2, June 1, 1999; http://www.isprs.org/publications/highlights/highlights0402/fritz.html, accessed May 21, 2006.

Fujimura, Joan. "Constructing Do-able Problems in Cancer Research: Articulating

Alignment," *Social Studies of Science*, Vol. 17, 1987, 257-293.

Gabriele, Mark David. "How Open Will the Skies Really Be?," in Baker, O'Connell and Williamson, 449-462.

Gabrynowicz, Joanne, comments in Advisory Committee for Commercial Remote Sensing (ACCRES), National Oceanic and Atmospheric Administration (NOAA), Open Session Meeting Summary [7th Meeting], September 13, 2005; http://www.accres.noaa.gov/7thMeeting09-13-05.pdf, accessed September 14, 2007.

Gabrynowicz, Joanne I., interview in Bates, Jason, "Teaching the Legal Aspects of Space Activity, *Space News*, April 19, 2004; http://www.space.com/spacenews/archive04/joannearch_040504.html accessed on 11 September 2005.

Gabrynowicz, Joanne I., videotaped lectures on course entitled Space Studies 575: Remote Sensing Policy & Law, Grand Forks, ND: University of North Dakota, Spring 2001.

Gabrynowicz, Joanne I. *The Land Remote Sensing Laws and Policies of National Governments: A Global Survey*, University, MS: University of Mississippi Law School, National Center for Remote Sensing, Air, and Space Law, January 3, 2007; http://www.spacelaw.olemiss.edu/activitiesandevents/2007/ RS%20Law%20Global%20Survey.pdf, accessed May 26, 2007.

Gabrynowicz, Joanne I. "The Promise and Problems of the Land Remote Sensing Policy Act of 1992," *Space Policy*, Vol. 9, No. 4, November 1993, 319-328.

Gallucci, Robert, statements in U.S. House of Representatives; Committee on Science, Space, and Technology and Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 63, 73.

Galway, Jeffrey S. "Defense Remote Sensing Working Group (DRSWG)" (briefing), Washington, DC: NOAA Workshop on Commercial Remote Sensing Licensing, September 14, 2005, 1.

Gates, John and John Weikel. "Imagery and Mapping Support to the Ecuador-Peru Peace Process," in Baker, O'Connell and Williamson, 311-325.

Geoeye. "Employment Opportunities;" http://geoeye.com/corporate/jobs.htm, accessed February 10, 2007.

GeoEye (main website); http://www.geoeye.com, accessed May 27, 2006.

_____, "GeoWorld Interview: Herb Satterlee, CEO, Digital Globe;" http://www.geoplace.com/gr/interview/satterlee.asp, accessed May 27, 2006.

Gertz, Bill. "Crowding in on the High Ground," *Air Force Magazine Online*, Vol. 80, No. 4 (April 1997); http://www.afa.org/magazine/April1997/0497crowding.asp, accessed August 21, 2005.

Gilbert, Justin, Weidner University law student, comment (during casual conversation).

Gieryn, Thomas F. "Boundaries of Science," in Sheila Jasanoff, Gerald E. Jarkle, James C. Petersen and Trevor Pinch, eds. *Handbook of Science and Technology Studies*, Thousand Oaks, CA: Sage Publications, 1994, 393-443.

Gildea, Kerry. "Clapper: NIMA Unlikely to Enter Exclusive Access Deals for Commercial Industry," *Defense Daily Network*, June 6, 2002; http://www.defensedaily.com/cgi/catalog/sample?C4I, accessed February 5, 2006).

Gildea, Kerry. Lawmakers Put Pressure on DoD to Devise Commercial Imagery Strategy," *Defense Daily Network*, June 6, 2002; http://www.defensedaily.com/cgi/catalog/sample?C4I#A3, accessed February 5, 2006.

GIS Development (main website); http://www.gisdevelopment.net/news/2001/jan/airborn.htm, accessed May 27, 2006.

Glickman, Dan, statements in U.S. House of Representatives; Committee on Science, Space, and Technology and Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 11, 71.

Global Marketing Insights, Inc. "Survey and Analysis of Remote Sensing Market, Aerial and Spaceborne, September 2005; http://www.licensing.noaa.gov/Survey/Analysis,pdf, accessed September 9, 2007.

Gore, Al, statement in U.S. Senate, Committee on Commerce, Science, and Technology; Subcommittee on Science, Technology and Space, *S. 2297, The Land Remote Sensing Policy Act of 1992* (hearing), 102nd Congress, Washington, DC: U.S. Government Printing Office, 1992, 1.

Grahn, Sven. "The Quickbird-1 Launch Failure;" http://www.svengrahn.pp.se/histind/Quickbird/Quickbird.html, accessed June 11, 2006.

Grahn, Sven. "The US-A program (Radar Ocean Reconnaissance Satellites – RORSAT) and radio observations thereof;" http://www.svengrahn.pp.se/trackind/RORSAT/RORSAT.html, accessed October 30, 2005.

Greenberg, Daniel S. "Bring Back OTA – Congress' Own Think Tank – Legislators need objective scientific advice," *The Scientist*, May 19, 2003; http://www.freerepublic.com/focus/f-news/914740/posts, accessed September 3, 2007.

Grundhauser, Larry K. "Sentinels Rising: Commercial High-Resolution Imagery and Its Implications of US National Security, *Airpower Journal*, Vol. 12. No. 4, Winter 1998, 61-80.

Gupta, Vipin. "New Satellite Images For Sale: The Opportunities and Risks Ahead," *International Security*, Vol. 20, No. 1, Summer 1995, 94-125.

Gupta, Vipin, "New Satellite Images For Sale: The Opportunities and Risks Ahead, (webpage section entitled "Policy Developments on Sale of High-Resolution Satellite Imagery); http://www.llnl.gov/csts/publications/gupta/pd.html, accessed October 2, 2005.

Gupta, Vipin and Adam Bernstein, "Keeping an Eye on the Island: Cooperative Remote Monitoring in the South China Sea," in Baker, O'Connell and Williamson, 341-345 and 327-360. .

Hagen, Regina. "Stop Cassini Earth Flyby," August 11, 1988, http://www.astronautix.com/craft/usa.htm, accessed October 30, 2005.

Hall, Doug, comments in Advisory Committee for Commercial Remote Sensing (ACCRES), National Oceanic and Atmospheric Administration (NOAA), Open Session Meeting Summary [7th Meeting], Swptember 13, 2005, 4; http://www.accres.noaa.gov/7thMeeting09-13-05.pdf, accessed September 14, 2007.

Hall, Keith R., statement in U.S. House of Representatives, Committee on Science, Space, and Technology and Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 55.

Hanley, Colleen. "Regulating Commercial Remote Sensing Satellites Over Israel: A Black Hole in the Open Skies Doctrine," *Administrative Law Review*, (no date, online version), Washington, DC: American University, 1; http://www.wcl.amercian.edu/journal/alr/52/52-1hanley.pdf?rd=1, accessed July 1, 2006

Hardin, R. Winn. "Remote sensing satellite market pits industry against U.S. policy," *OE Reports*, No. 185m May 1999, 2; http://www.spie.org/web/oer/may/may99/home.html, accessed February 6, 2006

Harraway, Donna J. *Simians, Cyborgs, and Women: The Reinvention of Nature*, NY: Routledge, 1991.

Harris, Jeffrey K, statement in U.S. House of Representatives, Committee on Science, Subcommittee on Space and Aeronautics, "The Commercial Space Act of 1997, Part I: Commercial Remote Sensing (hearing), 10, 12;

http://commDOCs.house.gov/committees/science/hsy141160.000/hsy 141160_0.htm, accessed October 30, 2005.

Herring, Chuck, telephone conversation, October 5, 2004.

Hinderstein, Corey G. "Uses of High-Resolution Commercial Satellite Imagery for Nuclear Nonproliferation" in Michael Jeffee and Joseph Bassi, "High-Resolution Earth Observation from Space: What are Today's Issues?, Symposium Summary (Washington, DC: Space Policy Institute, George Washington University, and University, MS: Space Law Center, University of Mississippi School of Law, December 18, 2001), 4-5; http://www.gw.uedu/~spi/Dec18EO.pdf, accessed November 28, 2005.

Hitchens, Theresa. "Commercial Imagery: Benefits and Risks" (speech delivered at a conference entitled "U.S. Space Operations in the International Context, Washington, DC: Center for Defense Information, March 3, 2004); http://www.cdi.org/program/document.cfm?DocumentID=2111& from_page=../index.cf..., accessed April 23, 2006.

Holler, Linda L. and Melvin S. Sakazaki, "Commercial Space and United States National Security" (paper prepared for the Commission to Assess United States National Security Space Management and Organization, no date; Commission Report dated January 11, 2001; http://www.fas.org/spp/eprint/article06.html#rft50, accessed February 4, 2006

Hollings, Ernest F., statement in U.S. Senate, Committee on Commerce, Science, and Technology, Subcommittee on Science, Technology and Space, *S. 2297, The Land Remote Sensing Policy Act of 1992*, 3.

Howe, Jr., Jerald S. "U.S. Space Industrial Competitiveness: Legal and Regulatory Issues," in U.S. Congress, House of Representatives, Committee on Science, Space and Technology, Subcommittee on Space, *The Future of the U.S. Space Industrial Base* (hearings), 191-209.

_____; http://www.state.gov/t/np/rls/other/32887.htm#ecnp0, accessed January 29, 2006 (since discontinued).

_____; http://www.state.gov/t/ac/16188.htm, accessed January 29, 2006.

Hughes, Thomas P. *Networks of Power: Electrification in Western Society, 1880-1930*, Baltimore, MD: Johns Hopkins University Press, 1993.

Hughes, Thomas P. "The Evolution of Large Technological Systems," in Bijker, Hughes and Pinch, 51-82.

______, "IAI EROS Commercial Satellite Launched Successfully," *Israel High-Tech and*

Investment Report, January 2001; http://www.ishitech.co.il/jan01ar2.htm, accessed May 27, 2006.

Iannotta, Ben. "Setting the rules for remote sensing," *Aerospace America*, Vol. 3. No. 4, April 1999, 34-38.

______, "IKONOS Data Guide," Durham, NH: University of New Hampshire, website, last updated July 7, 2003; http://eos-webster.sr.unh.edu/data_guides/ikonos_dg.jsp, accessed October 31, 2005.

ImageSat International. "EROS A," ImageSat (2005); http://www.imagesatintl.com/?catid={D76C171A-56A7-48F4-B49C-C4FB14212FD7}, both accessed May 27, 2006.

ImageSat International. "EROS Satellites," 2005; http://imagesatintl.com/default.asp?catid={C3836EE-A141-4314-9E7D-B137378069F5}, accessed May 27, 2006.

Industrial College of the Armed Forces, National Defense University. Spring 2003 Industry Study Final Report: Space Industry (Washington, DC, 2003); http://www.ndu.edu/ICAF/industry/reports/2003/pdf/2003_SPACE.pdf, accessed September 9, 2007.

Inlow, Roland S. "National Security Considerations: Impact on Intelligence Sources and Methods," in McDonald, 56-64.

_____, "Interview: Understanding the Future of Commercial Remote Sensing, *PE&RS*, Vol. 66. No. 1, January 2000; http://www.asprs.org/publications/pers/2000journal/january/interview.html, accessed October 16, 2005.

Isbell, Douglas. "Mission To Planet Earth Enterprise Name Changed to Earth Science [Press] Release: 98-12," Washington, DC: NASA, January 21, 1998; http://www.gsfc.nasa.gov/news-release/releases/1998/h98-12.htm, accessed April 10, 2006

Jackson-Lee, Sheila, comments in U.S. House of Representatives, Committee on Science, Subcommittee on Space and Aeronautics, Committee on Science, Hearings on the Commercial Space Act of 1997, Part III, 114; http://commDOCs.house.gov/committees/science/hsy141160.000/hsy141160_0.htm, accessed October 31, 2005.

Jakhu, Ram "International Law Governing the Acquisition and Dissemination of Satellite Imagery," in Keeley and Huebert, 11-30.

Jasanoff, Sheila. *The Fifth Branch: Science Advisers as Policymakers*, Cambridge, MA:

Harvard University Press, 1990.

Jet Propulsion Laboratory, National Aeronautics and Space Administration. "SeaWiFS. SeaStar;" http://samadhi.jpl.nasa.gov/msl/QuickLooks/seastarQL.html, accessed October 31, 2005.

John R. Jensen, statement in U.S. Senate, Committee on Commerce, Science, and Transportation, Subcommittee on Science, Technology, and Space, S. 2297, *The Land Remote Sensing Policy Act of 1992* (hearing), 55

Johnson, Richard G. "Supporting the Dayton Peace Talks," in Baker, O'Connell and Williamson, 297-310.

Jones, Dennis. "Commercial Remote Sensing and National Security," *Crosslink*, Vol. 5, No. 2, 2004; http://www.aero.org/publications/crosslink/summer2004/09.html, accessed June 7, 2006.

Johnson, Richard G. "Supporting the Dayton Peace Talks," in Baker, O'Connell and Williamson, 287-310.

Jurkevics, Edward, quoted in Roger Fillion, "Orbit of change for satellite firms. Pared-down industry gets set to launch new-ear technology," *Rocky Mountain News*, January 9, 2006; http://www.rockymountainnews.com/drmn/tech/article/0,2777,DRMN_23910_4373447,00.html, accessed March 26, 2006.

Keeley, James F. and Rob Huebert, eds. *Commercial Satellite Imagery and United Nations Peacekeeping: A View From Above*, Burlington, VT: Ashgate Publishing Company, 2004, 15.

Kim, Roger Jung-ho, statement (September 15, 2996) recorded by Ken Thompson, rappateur, during the Commercial Remote Sensing Satellite Symposium, September 13-15, 2006 held in Washington, DC.

Kim, Tae-gyu. "KOREA: Korea joins world's satellite powers," *Korea Times* (August 22, 2006; http://www.asiamedia.ucla.edu/article.asp?parentid=51389, accessed May 18, 2007.

Kitchin, Rob. *Cyberspace: The World in the Wires*, NY: John Wiley & Sons, 2000.

Krepon, Michael, et. al., eds. *Commercial Observation Satellites and International Security*, NY: St. Martin's Press, 1990.

Krepon, Michael. "The New Hierarchy in Space," in Krepon, et. al., 16-32.

Kuhn, Thomas. *The Structure of Scientific Revolutions*, 2nd edition, Chicago: The University of Chicago Press, 1970.

Land Remote Sensing Commercialization Act of 1984 (P.L. 98-365), July 17, 1984; available at website of the Society of Environmental Journalists at: http://www.sej.org/foia/PL98-365.txt, accessed July 1, 2006.

Land Remote Sensing Policy Act of 1992 (P.L. 102–555), October 28, 1992; available at NASA website at: http://geo.arc.nasa.gov/sge/landsat/15USCch82.html, accessed July 9, 2006. Subchapter II in Appendix B of this dissertation).

_____, "Landsat-4/-5," eoPortal Directory; http://directory.eoportal.org/pres_Landsat4and5.html, accessed June 2, 2007.

Lauer, Donald T. An Evaluation of National Policies Governing the United States Civilian Satellite Land Remote Sensing Program, Ph.D. dissertation, Santa Barbara, CA: University of California at Santa Barbara, 1990.

Latour, Bruno. *Science in Action*, Cambridge, MA: Harvard University Press, 1987.

Lewis, James A. *Preserving America's Strength in Satellite Technology: A Report of the CSIS Satellite Commission*, Washington, DC: The CSIS Press, April 2002, 23.

Lewis, James A. "Remote Sensing Satellites and Presidential Decision Directive-23," Washington, DC: Center for Strategic and International Studies, March 5, 2002; http://www.csis.org/media/csis/pubs/030502_remotesensing_sats_pdd23.pdf, accessed September 2005.

Long, Richard D. Long, *Report No. 08016-1-SF; Follow-Up Review of Forest Service Security Over Aircraft and Aircraft Facilities*, Washington, DC: U.S. Department of Agriculture, September 30, 2003), 31.

Luke, Timothy, comments during S+T Policy Institute (scoping session), Blacksburg, VA, April 7, 2006.

Luttwak, Edward. "From Geopolitics to Geo-Economics: Logic of Conflict, Grammar of Commerce," *The National Interest* (Summer 1990), 17-23.

Macauley, Molly K., statement in U.S. House of Representatives, Committee on Science, Subcommittee on Space (hearings on the "Commercialization of Space"), May 21, 1997; http://www.house.gov/science/macauley_5-21.html, accessed June 23, 2006.

Macauley, Molly K. and Timothy J. Brennan. "Enforcing Environmental Regulation: Implications of Remote Sensing Technology" (Discussion Paper 98-33), Washington, DC: Resources for the Future, 1998.

Mack, Pamela E. *Viewing the Earth: The Social Construction of the Landsat Satellite System*, Cambridge, MA: The MIT Press, 1990.

MacInnes, Andrew, comments in Ken Thompson.

MacKenzie, Donald. *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance*, Cambridge, MA: The MIT Press, 1990.

MacKenzie, Donald. "Missile Accuracy: A Case Study in the Social Processes of Technological Change, in Bijker, Hughes and Pinch, 195-222.

_____, Manfred Lachs Space Law Moot Court Competition 2001; http://www.spacemoot.org/acrobat/2001_1R.pdf, accessed 5 Sept 05.

Maloney, Patricia, comments tape-recorded by Ken Thompson during the Commercial Remote Sensing Satellite Symposium, 13-15 September 2006, Washington, DC.

Marom, Dror. "Israel: Germany freezes support for 'David' joint satellite project," (posting on German website Globes [online]), February 10, 2003; http://www.imra.org.il/story.php3?id=15757, accessed May 28, 2006.

Matthews, Sally. "Worldwide Trends in Geographic Information Systems," Access America (USG website) (no date); http://govinfo.libary.unt.edu/accessamerica/dogs/gis.html, accessed January 20, 2007

Mayer, Matthew. "Commercial Remote Sensing," in Industrial College of the Armed Forces, National Defense University, Spring 2003 Industry Study: Final Report – Space Industry, Washington, DC: Spring 2003; http://www.ndu.edu/ICAF/industry/reports/2003/pdf/2003_SPACE.pdf, accessed September 9, 2007.

Mayer, Matthew. "Commercial Remote Sensing," *Spring 2003 Industry Study: Final Report – Space Industry*. Ft. McNair, Washington, DC: Spring 2003; http://www.ndu.edu/ICAF/industry/IS2003/papers/2003%20Space.htm, accessed November 26, 2005.

McDonald, Robert A., ed. *Proceedings: Space Imagery and News Gathering for the 1990s: So What?* (Symposium on Foreign Policy and Remote Sensing at the University of Kentucky), Bethesda, MD: American Society for Photogrammetry and Remote Sensing, 1991

Memorandum of Understanding Among the Departments of State, Defense, Commerce, Interior and the Intelligence Community Concerning the Licensing of Private Remote Sensing Satellite Systems, Washington, DC: January 4, 2000; http://www.accres.noaa.gov/MOU1-4-200.pdf, accessed June 17, 2006.

Miller, Ernest. "Features: US Wields $ Not Law to Censor Satellites," *LawMeme*, New Haven: CN: Yale University Law School, 20 Oct 2001;

http://research.yal.edu/lawmeme/modules.php?name=News&file+article&side+114, accessed October 8, 2005.

Mondello, Charles, George F. Hepner and Ray A. Williamson. *10-Year Industry Forecast, phase I-III – Study Documentation*, Bethesda, MD: ASPRS, January 2004 (also carried in *Photogrammetric Engineering and Remote Sensing (PE&RS)*, Vol. 70, No. 1, January 2004), 7-58.

Mondello, Charles, George F. Hepner and Ray A. Williamson. *10-Year Remote Sensing Industry Forecast: Phase IV*, Bethesda, MD: ASPRS, September 2006 (also carried in *PE&RS*, Vol. 72, No. 9, September 2006, 987-1000

Moorman, Jr., Thomas S. "The Explosion of Commercial Space and The Implications for National Security," *Aerospace Power Journal*, Spring 1999, 6-20.

Moran, Susan, statement in U.S. House of Representatives, *The Commercial Act of 1997, Part 1: Commercial Remote Sensing*, Hearings (May 21, 1997); http://commDOCs.house.gov/committees/science/hsy141160.000/hsy141160_0htm, accessed October 31, 2005.

Motta, Mary. "Space Imaging President Moves to Lockheed;" http://ww.space.com/businesstechnology/business/imaging_breaking_000508.html, accessed April 27, 2006.

National Aeronautics and Space Administration. "Explorer-6," April 6, 2005; http://nssdc.gsfc.nasa.gov/database/MasterCatalog?sc=1959-004A, accessed May 27, 2006.

National Aeronautics and Space Administration, "Landsat Program Chronology;" http://geo.arc.nasa.gov/sge/landsat/lpchron.html, accessed July 1, 2006.

National Aeronautics and Space Administration. "SPACE/DATA - Online and Other sources of Images and Data," March 1, 1994; http://www.ksc.nasa.gov/facts/faq03.html, accessed April 2, 2006.

National Aeronautics and Space Administration, "Terra • Aqua • Aura: Earth Observing Systems of Environmental Satellite Systems;" http://www.spacetoday.org/Satellites/TerraAqua/TerraAquaAura.html, accessed May 19, 2007.

National Aeronautics and Space Administration, National Oceanic and Atmospheric Administration, and U.S. Geological Survey. "Management Plan for the Landsat Program," (August 10, 1994); http://geo.arc.nasa.gov/sge/landsat/mgmtplan.html, accessed May 24, 2007.

National Academy of Public Administration. "Space Remote Sensing and the Private

Sector: An Essay," DOC Contract No. NA-93-SAC-066, March 1983.

National Center for Remote Sensing, Air, and Space Law. The Land Remote Sensing Laws and Policies of National Governments: A Global Survey, University, MS: University of Mississippi (Law School), January 3, 2007, xi; http://www.licensing.noaa.gov/NOAARemoteSensing_LawGlobalSurvey.pdf, accessed November 21, 2007.

National Center for Remote Sensing, Air and Space Law (website), The University of Mississippi; http://www.spacelaw.olemiss.edu/, accessed November 19, 2006.

National Commission for the Review of the National Reconnaissance Office. *Report of the National Commission for the Review of the National Reconnaissance Office: Preparing the NRO for the Future*; http://www.fas.org/irp/nro/commission/prepare.htm, accessed November 30, 2005.

National Oceanic and Atmospheric Administration. "April 1, 1960 – TIROS;" http://noaasis.noaa.gov/NOAASIS/ml/40yearsa.html, accessed May 14, 2006.

National Oceanic and Atmospheric Administration. "Ed Morris Named Office of Space Commercialization Director" (press release 2006-R300), February 1, 2006; http://www.publicaffairs.noaa.gov/releases2006/feb06/noaa06-r300.html, accessed April 22, 2006.

National Oceanic and Atmospheric Administration (webpage on CRS licensees); http://www.licensing.noaa.gov/licensees.html, accessed October 14, 2006.

National Research Council, Space Studies Board. *Toward New Partnerships In Remote Sensing: Government, the Private Sector, and Earth Science Research*, Washington, DC: The National Academies Press, 2002.

_____, "National Security Directives (NSD) [George H. W. Bush Administration, 1989-93]; http://fas.org/irp/offdocs/nsd/index.html, accessed November 6, 2005.

_____, "National Security Presidential Directives [NSPD] George W. Bush Administration," http://fas.org.irp/offdocs/index..html, accessed November 6, 2005.

_____, "National Space Policy," (editorial comments on the National Security Decision Directive Number 42, July 4, 1982 of the Regan administration); http://www.hq.nasa.gov/office/pao/History/ndss-42.html, accessed June 3, 2006.

Neer, John. "Luddite Editor?," *Technology Review*, Vol. 102, No. 3, May-June 1999, 15.

Norris, Peter M. P. "Landsat Multispectral and Thematic Mapper Imagery–What Is Commercially Available Today and Planned for the Future," in McDonald, 18-24.

Novariant, Inc. "Novariant Names Herb Satterlee New CEO, Seasoned leadership in Agriculture and high-tech industries" (press release), February 14, 2006; http://www.novariant.com/news/pdfs/Herb%20satterlee%20Novariant%20CEO.pdf, accessed July 21, 2006.

_____, "NSDD-National Security Decision Directives Regan Administration;" http://fas.org.irp/offdocs/index.html, accessed November 6, 2005.

Oberg, James. "Spying for Dummies: The National Security Implications of Commercial Space Imaging," on Oberg's website at: http://jamesoberg.com/articles/spy/, accessed May 28, 2006.

Oberg, James. "Spying for Dummies," *IEEE Spectrum*, Vol. 36, No. 11, November 1999, 62-69.

Oberg, James. "Spying for Dummies: The National Security Implications of Commercial Space Imaging," *Spectrum*, November 1999; http://jamesoberg.com/articles/spy/, accessed May 28, 2006.

Oborne, Michael, ed. *Space 2030: Tackling Society's Challenges*, Paris, France: Organisation for Economic Co-Operation and Development, 2005.

O'Connell, Kevin, et. al. *U.S. Commercial Remote Sensing Satellite Industry: An Analysis of Risks* (Santa Monica, CA: RAND, 2001), xi, 2, 65

O'Connell, Kevin and Beth E. Lachman. "From Space Imagery to Information: Commercial Remote Sensing Market Factors and Trends," in Baker, O'Connell and Williamson, 43-78.

O'Connell, Kevin M. and Gregory Hilgenberg. "U.S. Remote Sensing Programs, and Policies," in Baker, O'Connell and Williamson, 139-163.

O'Connell, Mathew, quoted in Joanna Glasner, "Satellites Will See More, Faster," Wired News, March 17, 2006; http://www.wired.com/news/technology/1,70267-0.html, November 15, 2006.

O'Connell, Mathew, comments in Ken Thompson, 22.

O'Connell, Mathew, comments tape-recorded by Ken Thompson during the Commercial Remote Sensing Satellite Symposium, 13-15 September 2006, Washington, DC.

Office of Geographical Information Systems and Remote Sensing (OGIS website), Virginia Polytechnic Institute and State University; http://ecs.lib.vt.edu/VT_OGIS/wwwmain.html, accessed November 19, 2006.

Office of Space Commercialization, NOAA, Department of Commerce. "FAQ;"

http://www.nesdis.noaa.gov/space/about/faq.html, accessed April 22, 2006.

Office of Space Commercialization, NOAA, Department of Commerce. "GIS Capabilities for Civil Government Organizations: Building a Bridge to a Safe, Secure, and Prosperous Future (Speaker Biographies); http://www.nesdis.noaa.gov/space/library/workshops/2006-10-19/biographies.html, accessed May 30, 2007.

Office of Space Commercialization, NOAA, Department of Commerce. "Satellite Imaging," http://www.nesdis.noaa.gov/space/imaging/, accessed April 22, 2006.

Office of Technology Assessment. *Civilian Satellite Remote Sensing: A Strategic Approach, OTA-ISS-607*, Washington, DC: U.S. Government Printing Office, September 1994.

Office of Technology Assessment. *Civilian Space Policy and Applications*, Washington, DC: U.S. Government Printing Office, June 1982.

Office of Technology Assessment. *Remote Sensing and the Private Sector: Issue for Discussion – A Technical Memorandum, OTA-TM-ISC-20*, Washington, DC: U.S. Government Printing Office, March 1984.

Office of Technology Assessment. *UNISPACE '82: A Context for International Cooperation and Competition, A Technical Manual*, Washington, DC: U.S. Government Printing Office, March 1983.

Opall-Rome, Barbara. "Israel Building New Radar Satellite," *C^4ISR* (March 4, 2005); http://www.isrjournal.com/story.php?F=700606, accessed April 2, 2006.

_____, "ORBIMAGE Completes Acquisition of Space Imaging, Changes Brand Name to GeoEye;" http://www.orbimage-acquisition.com/news/geoEye.htm**,** accessed February 26, 2006.

Orbimage. "ORBIMAGE Finalizes Agreement with NOAA to Provide Image Data for Environmental Research," October 28, 2005; http://www.orbimage.com/news/releases/10-28-05.html, accessed October 31, 2005.

Orbital Sciences Corporation, "Orbview-3;" http://www.orbital.com/SatellitesSpace/LEO/OV3/, accessed June 11, 2006.

______, "Orbview;" http://www.astronautix.com/craft/orbview.htm, accessed June 11, 2006.

____, "The OTA Legacy; http://www.wws.princeton.edu/ota/, accessed April 22, 2006.

Pace, Scott, Brant Sponberg and Molly Macauley. *Data Policy Issues and Barriers to Using Commercial Resources for Mission to Planet Earth*, Santa Monica, CA: RAND, 1999.

Pace, Scott. *Merchants and Guardians: Balancing U.S. Commercial Interests in Space Commerce*, RP-787, Santa Monica, CA: RAND, 1999.

Pace, Scott, statement in ______, "Emerging Intellectual Property Rights and Other Policy Issues with the Commercialization of Remote Sensing," notes taken during a CRESS Seminar, College Park, MD: University of Maryland, Department of Geography, April 29, 1988; http://www.geog.umd.edu/cress/s-pace.htm, accessed October 31, 2005.

Pace, Scott, statement in U.S. House of Representatives, Committee on Science, Space, and Technology and the House Permanent Select Committee on Intelligence, Commercial *Remote Sensing in the Post-Cold War Era*, 29, 91.

Pace, Scott, statement in U.S. House of Representatives, Committee on Science, Subcommittee on Basic Research, Using Commercial Data Sources in the Earth Science Enterprise (hearings), September 28, 1998; http://www.house.gov/science/pace_09-28.htm, accessed October 31, 2005.

Pace, statement in U.S. House of Representatives, Subcommittee on Basic Research, "Using Commercial Data Sources in the Earth Science Enterprise," Washington, DC: September 28, 1998; http://www.house.gov/science/pace_09-28.htm, accessed April 10, 2006.

Pace, Scott, et. al. *The Earth Below: Purchasing Science Data and the Role of Public-Private Partnerships*, Santa Monica, CA: RAND, 2000.

Paul, Rajesh, Siva Subramanian and Shalabh Bharadwaj. "Creation of Digital City Model using Single High Resolution Satellite Imagery," *PE&RS*, Vol. 72, No. 4, April 2006, 341-342.

______, "Policy Development on Sale of High-Resolution Satellite Imagery;" http://www.llnl.gov/csts/publications/gupta/pd.html#russia, accessed October 31, 2005.

Perrow, Charles. *Normal Accidents: Living with High-Risk Technologies*, NY: Basic Books, Inc., 1984.

_____, "Presidential Directives (PD) and Presidential Review Memoranda (PRM)," Atlanta, GA: Jimmy Carter Library and Museum; http://www.jimmycarterlibrary.org/documents/pddirectives/pres_directive, accessed June 3, 2006.

_____, "Presidential Directives (PD) [Carter Administration, 1977-81]," http://fas.org.irp/offdocts/index.html, accessed November 6, 2005.

_____, "Presidential Decision Directives [PDD] Clinton Administration 1993-2000; http://fas.org/irp/offdoccs/pdd, accessed November 6, 2005.

Preston, Bob. "Emerging Technology: Emerging Issues for Space Remote Sensing," in Baker, O'Connell, and Williamson, 79-100.

Robert Preston, "Space Remote Sensing Regulatory Landscape," in Baker, O'Connell and Williamson, 501-531.

_____, "QuickBird 1 Kosmos Launch Fails," *SPACEandTECH Digest* (November 21, 2000); http://www.spaceandtech.com/digest/flash-articles/flash2000-087.shtml, accessed May 30, 2007.

______, "Quickbird-2; http://directory.eoportal.org/pres_QUICKBIRD2.html, accessed June 11, 2006.

_____, " RADARSAT-2;" http://directory.eoportal.org/pres_RADARSAT2.html, accessed November 15, 2006.

Radzanowski, David P. *CRS Report to Congress: The Future of Land Remote Sensing Satellite System (Landsat),* Washington, DC: Congressional Research Service, September 16, 1991.

_____, "Remote Sensing Interagency Working Group" (slide briefing), NOAA Workshop on Commercial Remote Sensing Licensing, 2.

_____, "Remote Sensing Then and Now, Leap Into Space," CCRS; http://ccrs.nrcan.gc.ca/org/history/history2_e.php, accessed April 2, 2006.

Roby, Cheryl, statement in U.S. House of Representatives, Committee on Science, Subcommittee on Space and Aeronautics, Hearings on the Commercial Space Act of 1997, Part III: Commercial Remote Sensing, June 4, 1997, 104; http://commDOCs.house.gov/committees/science/hsy141160.000/hsy141160_0.htm, accessed October 31, 2005.

Roby, Cheryl. "Statement for the Record of Ms. Cheryl, Principle Director for Intelligence (Intelligence and Security), Office of the Assistant Secretary of Defense)," (Hearings on H.R. 1702), Washington: U.S. House of Representatives; Subcommittee on Space and Aeronautics; Committee on Science, June 4, 1997; http://www.house.gov/science/roby_5-4.html, accessed February 8, 2006.

Robson, David W. "Cognitive Rigidity; methods to overcome it," (undated paper); http://analysis.mitre.org/proceedings/Final_Papers_Files/40_Camera_Ready_Paper.pdf, accessed February 10, 2007.

Rohrabacher, Dana, comments in U.S. House of Representatives, Committee on Science, Subcommittee on Space and Aeronautics, Hearings on the Commercial Space Act of 1997, Part I: Commercial Remote Sensing, (May 21, 1997), 3; http://commdocs.house.gov/committees/science/hsy141160.000/hsy141160_0.htm, accessed September 9, 2005.

Rohrabacher, Dana, statement in U.S. House of Representatives, Committee on Science, Subcommittee on Space and Aeronautics, Hearings on the Commercial Space Act of 1997, Part III: Commercial Remote Sensing (June 4, 1997), 89-90; http://commDOCs.house.gov/committees/science/hsy141160.000/hsy141160_0.htm, accessed October 31, 2005.

Rohrabacher, Dana, statement in U.S. Congress, Committee on Science, Space, and Technology and the Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 74.

Rowberg, Richard E. *Commercial Remote Sensing by Satellite: Status and Issues*, Washington, DC: Congressional Research Service, Library of Congress, January 8, 2002.

SAIC, advertisement, *Photogrammetric Engineering and Remote Sensing*, Vol. 72, No. 4, April 2006), 466.

Sandalow, David B. "Remote Sensing and Foreign Policy" (remarks delivered at the Symposium on "Viewing the Earth: The Role of Satellite Earth Observations and Global Monitoring in International Affairs)," Washington, DC, The George Washington University, June 6, 2000; http://www.gwu.edu/~spi/vtespeech.html, accessed February 11, 2006.

______, "Satellite Operating Partner Program," ImageSat International; http://www.imagesatintl.com/?catid= C430687B-FB8B-4CCC-B3B9-EDC528B0D044, accessed August 27, 2005.

Scharf, J. Laurent. "News Dissemination of Images From Remote-Sensing Imagery First Amendment Standards for Judging National Security Risks," in McDonald, 48-55.

Scheuer, James H., statement in U.S. House of Representatives; Committee on Science, Space, and Technology; Subcommittee on Environment, *The Landsat Program Management plan and H.R. 3614, National Land Remote-Sensing Policy Act of 1991*, (Washington, DC: U.S. Government Printing Office, April 7 1991), 55.

Schutzberg, Adena. "Resource21 Aims High, Falls Hard," *Earth Observation Magazine* (online version), April-May 2004; http://www.eomonline.com/Common/Archives/2004aprmay/ 04aprmay_resource21.html, accessed November 10, 2006

Scott, Walter S., letter to the U.S. House of Representatives, Committee on Science, Space, and Technology and the House Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 148.

Scott, Walter, statement in U.S. House of Representatives; Committee on Science, Space, and Technology and Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 99.

_____, "Seasat;" http://www.astronautix.com/craft/seasat.htm, accessed November 15, 2006.

Shane, Jack Shane. "Licensing Jurisdiction for Space-Based Equipment/Export Issues for Research Universities," (Wiley Rein and Fielding LLP), May 12, 2005, 6; http://www.wrf.com/docs/events/1188.pdf, accessed June 18, 2006.

Sietzen, Frank, Jr. "A Clearview of NIMA's Commercial Imagery Use," *Geospatial Solutions*, March 1, 2003; http://www.geospatial-online.com/article/articleDetail.jsp?id=48147, accessed June 24, 2006.

Sietzen, Frank, Jr. "A ClearView of NIMA's Commercial Imagery Use," *Geospatial Solutions*, March 1, 2002; http://www.geospatial-online.com/geospatialsolutions/articleDetail.jsp?id=48147, accessed April 23, 2006.

Sietzen, Frank, Jr. "Advanced Imagery Raises the Ante: High-resolution imagery from a burgeoning commercial remote sensing industry may pose perplexing policy questions," *Aerospace America*, Sept 2001; http://www.aiaa.org/aerospace/Article.cfm?issuetocid=136&ArchiveIssueID=18 , accessed on September 4, 2005.

_____, "SKYNET4;" http://www.fas.org/spp/guide/uk/military/comm/skynet_4.htm, accessed December 3, 2005.

Smith, Marcia S. *U.S. Space Programs: Civilian, Military, and Commercial*, Congressional Research Service Brief for Congress, CRS-6, Washington, DC: Congressional Research Service, Library of Congress, February 28, 2005; http://www.au.af.mil/awc/awcgate/CRS/ib92011.pdf, accessed November 28, 2005.

Smith, Nick, statement in U.S. House of Representatives; Committee on Science, Space, and Technology and Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 78.

Smith, Susan. "The Care and Feeding of Commercial High Resolution Imagery Satellite Companies," *GIS Weekly*, 18-22 October 2004; http://www.10.giscafe.com/nbc/article/view_weekly.php?newsletter=1&run-/date=25-Oct-2004, accessed June 24, 2006.

Snyder, Greg Snyder. "Commercial Remote Sensing Data Transfer Guidelines" (briefing at the public session of NOAA's Advisory Committee for Commercial Remote Sensing (Open Session), Washington, DC, September 13, 2005.

Sokolski, Henry, ed. *Fighting Proliferation: New Concerns for the Nineties* (Maxwell AFB, AL: Air University Press, Sept. 1996.

Solcomhouse.com. "NASA Rainforest Deforestation Images:" http://www.solcomhouse.com/NASArainforest.htm, accessed December 8, 2007.

Sourbes-Verger, Isabelle and Xavier Pasco. "The French Pioneering Approach to Global Transparency," in Baker, O'Connell, and Williamson, 187-204.

Space Imaging. "ORBIMAGE Agreement to Purchase Assets of Space Imaging" (press release), September 16, 2005; http://www.spaceimaging.com/newsroom/2005_ceoStatement.htm, accessed October 10, 2005.

Space Imaging, "Space Imaging and Kodak Announce Delivery of Camera Payload Component for IKONOS 1 Satellite System," August 12, 1997; http://www.spaceimaging.com/newsroom/1997_kodak.htm, accessed April 27, 2006.

______. "Space Imaging Asia Formed in Seoul: Hyundai Space & Aircraft Co. Becomes Regional Affiliate of Space Imaging," *Business Wire* (October 28, 1994); http://www.highbeam.com/library/DOCfree.asp?DOCID=1G1:56972611 &ctrlInfo=Round18%3AMode18c%3ADOCG%3AResult&ao=, accessed on October 10, 2005.

_____, "Space Imaging Awarded License to Provide Half-Meter Resolution Commercial Satellite Imagery," spaceref; http://www.spaceref.ca/news/viewpr.html?pid=3630, accessed May 27, 2006.

Space Imaging, " Space Imaging Awarded License to Provide Half-Meter Resolution Commercial Satellite Imagery: Leading Provider of Visual Earth Information Poised to be the World's Only Source of Half-Meter Resolution Commercial Satellite Imagery," January 19, 2001; http://www.spaceimaging.com/newsroom/2001_Half_Meter.htm, accessed May 27, 2006.

_____, "Space Imaging Names Paul Tinney as Executive Vice President of Global Alliances," November 29, 2001; http://spatialnews.geocomm.com/dailynews/2001/nov/30/news4.html, accessed May 27, 2001.

_____, "Space Imaging Wins USGS Contract for Commercial Satellite Imagery, *redOrbit News*; http://www.redorbit.com/modules/news/tools.php?tool=print&id=62653,

accessed February 14, 2005.

_____, (untitled article); *Space News Business Report*, May 27, 2003; http://www.space.com/spacenews/archive03/editarch_052703.html, accessed January 16, 2007.

Spector, Leonard S. "The Not-so-Open Skies," in Krepon, et. al., 164-184.

_____, "SPOT-1/-2 (System Pour l'Observation de la Terra)," eoPortal Directory; http://directory.eoportal.org/pres_SPOT12SystmePourlObservationdelaTerre.html, accessed June 2, 2007.

______, "SPOT-1, -2, -3, -4 Satellite Source/Platform Abstract Document," (reviewed and revised on July 28, 2998); http://www-eosdis.ornl.gov/source_DOCuments/spot.html, accessed December 3, 2005.

Stadd, Courtney and Ronald J. Birk. "No Strings Attached? Commercial remote sensing companies hope that US government policy will keep pace with the industry's rapidly expanding needs," *Imaging Notes*, July-August 1999; http://www.imagingnotes.com/julaug99/ja99nost.htm, accessed September 12, 2004.

Star, Susan Leigh and James R. Griesemer. "Institutional Ecology, 'Translations,' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39," in Mario Biagioli, ed., *The Science Studies Reader*, NY: Routledge, 1999, 503-524.

Steinberg, Gerald M. "Commercial Observation Satellites in the Middle East and the Persian Gulf," in Baker, O'Connell, and Williamson, 224-245.

Steinberg, Gerald. "Dual-Use Aspects of Commercial High-Resolution Imaging Satellites," *Mideast Security and Policy Studies*, Vol. 37, February 1998; original publication unavailable; digital publication on line at: http://www.biu.ac.il/SOC/besa/books/37pub.html#I, accessed November 6, 2005.

Steinberg, Gerald M. "Satelite [sic] Capabilities Of Emerging Space-Competant [sic] States" (Ramat Gan, Israel: Bar-Ilan University, April 13, 2005); http://faculty.biu.ac.il/~steing/military/sat.htm, accessed April 2, 2006.

Stevens, Hampton. "Government Unlikely to Ban Commercial Space Imagery Sales," *Defense Information and Electronics Report*, October 12, 2001; http://www.globalsecurity.org/org/news/2001/011012-attack04.htm, accessed September 8, 2007.

Stillman, Dan. "A Growing Alliance: The Alliance for Earth Observations," *Observe* (IGES newsletter), Vol. 1, No. 2, August 2006, 4.

Stoney, William E. "Appendix B, The Past, Present and Future of the Medium- and High-Resolution Satellite World (Table A-1 – Data Characteristics of Current and Planned Land Imaging Satellites), " in Baker, O'Connell, and Ray A. Williamson, 579-587.

Stoney, William. "Foreign Land Imaging Satellite Programs," in Advisory Committee for Commercial Remote Sensing (ACCRES), National Oceanic and Atmospheric Administration (NOAA), Meeting Summary [2nd Meeting], January 14, 2003, 5; http://www.accress.noaa.gov/Draft-Meeting-Minutes.doc, accessed September 14, 2007.

Stoney, William E. ASPRS Guide to Land Imaging Satellites, September 7, 2006; http://www.asprs.org/news/satellites/ASPRS_DATABASE_090707.pdf, accessed September 15, 2007.

Stoney, ASPRS Guide To Land Imaging Satellites, November 8, 2004; http://www.asprs.org/news/satellites/ASPRS_DATABASE_110804.pdf, accessed June 1, 2007.

Stoney, William. "World Commercial Remote Sensing Satellite Database" (as of August 9, 2006); http://www.lincensing.noaa.gov/whatsnew2.html, accessed October 28, 2007.

Stryker, Timothy, comments in Advisory Committee on Commercial Remote Sensing (ACCRES), National Oceanic and Atmospheric Administration (NOAA), Summary of Meeting [1st Meeting], September 30, 2002, 3; http://www.accres.noaa.gov/accres_meeting_report.pdf, accessed September 14, 2007.

Timothy Stryker, Timothy. "Responses to NOAA's Request for Information on Its Licensing Programs," summary of comments in Advisory Committee on Commercial Remote Sensing (ACCRES), National Oceanic and Atmospheric Administration (NOAA), Draft Meeting Summary [4th Meeting], December 11, 2003, 3; http://www.accres.noaa.gov/Meeting_Report_Dec11.pdf, accessed September 14, 2007.

Stryker, comments in Advisory Committee on Commercial Remote Sensing (ACCRES), National Oceanic and Atmospheric Administration (NOAA), Open Session Meeting Summary [5th Meeting], August, 27, 2004, 4; http://www.accres.noaa.gov/Final9-16-04.pdf, accessed September 13, 2007.

Stryker, Timothy. "Responses to NOAA's Request for Information on Its Licensing Programs," draft meeting summary, NOAA Advisory Committee for Commercial Remote Sensing (ACCRES), December 11, 2003, 3; http://www.accres.noaa.gov/Meeting_Report_Dec11.pdf, accessed October 29, 2005.

Sweetman, Bill. "Spy Satellites: The Next Leap Forward," *Jane's International Defense*

Review, Vol. 30, January 1997, 26-32.

Tahu, George, John Baker, and Kevin O'Connell. "Expanding global access to civilian and commercial remote sensing data: implications and policy issues," *Space Policy*, Vol. 14, No. 3, August 1998, 179-188.

Tahu, George J. "Russian Remote Sensing Programs and Policies," in Baker, O'Connell and Williamson, 165-185.

Technica, Inc. "News From Technica;" http://www.technicainc.com/, accessed March 13, 2006.

Thomas, Jack E. "A Defense Department Perspective on National Security Considerations Relating to Media News Gathering by Space Imagery," in McDonald, 65-72.

Thompson, Allen. "Israeli spysat coverage, resolution," (message posted on newsgroup sci.space.policy), November 4, 1995; http://www.fas.org/military/programs/asat/at_950411.htm, accessed May 28, 2006.

Thompson, Ken, rapporteur. *Proceedings • Commercial Remote Sensing Satellite Symposium* (September 13`15, 2006), edited by Judith Carrodeguas, Dan Stillman, Ken Thompson, and Kay Weston, Washington, DC: Institute for Global Environmental Strategies, 2006; http://www.crssymposium.com/program/CRSSymposiumProceedings.pdf, accessed January 6, 2007.

Townshend, John, statement in U.S. House of Representatives, *The Commercial Act of 1997, Part 1: Commercial Remote Sensing* (hearings), May 21, 1997, 9.

Gearóid Ó Tuathail (Gerald Toal). At the End of Geopolitics? Reflections on a Plural Problem at the Century's End (paper), Blacksburg, VA: Virginia Polytechnic Institute and State University, 1996; http://www.nvc.vt.edu/toalg/Website/Publish/papers/End.htm, accessed December 8, 2007.

21st Century Nanotechnology Research and Development Act (PL 108-153), December 3, 2003.

United Nations, Principles relating to the remote sensing of the Earth from space, A/RES/41/65, New York, U.N. General Assembly, December 3, 1986; http://www.un.org/documents/ga/res/41/a41r065.htm, accessed July 29, 2006.

United Nations, Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, A/RES/21/2222 , New York, U.N. General Assembly, October 1967; http://www.un-documents.net/ost.htm, accessed September 9, 2007.

______, untitled document from a collaborative workshop of NASA personnel held in La Jolla, CA, Avninda Sharma, India: Innovation Labs LLC, October 8, 2003; http://www.innovationlabs.com/dryden/r2_introduction.html, accessed October 31, 2005.

_____, "US-A," http://ww2.astornautix.com, accessed October 20, 2005.

U.S. Chamber of Commerce, Space Enterprise Council, "National Space Policy Review: Remote Sensing" (no date); http://www.uschamber.com/space/policy/remotesensing2.htm, accessed September 11, 2005.

U.S. Congress, *Congressional Record: National Defense Authorization Act for Fiscal Year 1007*, Senate – June 26, 1996, Washington, DC: U.S. Government Printing Office, 1996.

______, "US declassifies super res satellite imagery," GeoPlace.com; http://www.geoplace.com/ge/2001/0301/0301enw1.asp, accessed May 27, 2006

______, "U.S. Export Constraints Impacting U.S. Content in Alenia Aerospazio Satellite," *SPACEandTECH*, August 5, 2002; http://www.spaceandtech.com/digest/sd2000-14/sd2000-14-009.shtml, accessed October 10, 2005.

U.S. House of Representatives, Committee on Science, Subcommittee on Space and Aeronautics, Hearings on the Commercial Space Act of 2003 (H.R. 3245) (November 5, 2003); http://www.louisdb.org/ch/viewphp?documentURL=hearnings/108/house/House-hearing-108-90164.html?v=1&q=commercial+space+act&published-Max=2007-09-30&max-results=10&cat=ch&pubminmonth=&pubmaxmonth=90-30&pubminyear=&pubmaxyear=2007, accessed September 9, 2007.

U.S. House of Representatives, Committee on Science, Subcommittee on Space and Aeronautics. "The Commercial Space Act of 1997, Part I: Commercial Remote Sensing (hearings), May 21, 1997; http://commDOCs.house.gov/committees/science/hsy141160.000/hsy141160_0.htm, accessed October 30, 2005.

U.S. House of Representatives, Committee on Science, Subcommittee on Space and Aeronautics. "The Commercial Space Act of 1997, Part III: Commercial Remote Sensing (hearings), June 4, 1997; http://commDOCs.house.gov/committees/science/hsy141160.000/hsy141160_0.htm, accessed October 30, 2005.

U.S. House of Representatives; Committee on Science, Space, and Technology; Subcommittee on Environment. *The Landsat Program Management Plan and H.R. 3614*, *National Land Remote-Sensing Policy Act of 1991*, (hearings), 102nd Congress, 2nd Session, Washington, DC: U.S. Government Printing Office, 1992.

U.S. House of Representatives, Committee on Science, Space, and Technology and Permanent Select Committee on Intelligence. *Commercial Remote Sensing in the Post-Cold War Era* (Joint Hearing, No. 124), 103rd Cong., 2nd Session, February 9, 1994, Washington, DC: U.S. Government Printing Office, 1994

______, "USGS Awards Contracts for Commercial Satellite Imagery," *Directions Magazine*, June 7, 2004; http://www.directionsmedia.net/newsletters.archive/index.php?ID=395, accessed February 14, 2006.

U.S. Geological Survey. "Commercial Remote Sensing Space Policy (CRSSP), Center for Earth Resources Observation and Science (EROS); http://crsp.usgs.gov, accessed September 4, 2005.

U.S. Geological Survey. "Policy History;" http://crsp.usgs.gov/background.php, accessed on September 4, 2005.

U.S. Geological Survey (website); http://eros.usgs.gov, accessed April 2, 2006.

_____, "U.S. Nanotechnology Policy – Missing the Point," Center for Responsible Nanotechnology (no date); http://www.crnano.org/us-policy.htm, accessed September 3, 2007.

U.S. Senate, Committee on Commerce, Science, and Technology, Subcommittee on Science, Technology and Space. *S. 2297, The Land Remote Sensing Policy Act of 1992* (hearings), 102nd Congress, Washington, DC: U.S. Government Printing Office, 1992.

U.S. Senate. Congressional Record: National Defense Authorization Act for Fiscal Year 1997, Amendment No. 4321, "Purpose: Prohibition on Collection and Release of Detailed Satellite Imagery Relating to Israel and Other Countries and Areas," Washington, DC, June 26, 1996.

U.S. Senate. Congressional Record: National Defense Authorization Act for Fiscal Year 1997 (Kyl-Bingaman Amendment), Sec. 1043: Prohibition on Collection and Release of Detailed Satellite Imagery Relating to Israel and Other Countries and Areas, Washington, DC, June 26, 1996.

Walker, Robert S., statement in U.S House of Representatives, Committee on Science, Space, and Technology and House Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post Cold War Era*, 35.

Wallace, Robert E. "Earthquakes, Minerals and Me: With the USGS, 1942-1995" (U.S. Geological Survey Open-File Report 96-260), 1996;

http://quake.wr.usgs.gov/research/history/wallace-XI.html, accessed 2 April 2006.

______, "West Indian Space Changes Name to ImageSat, Announces Product Offerings," Andrews Space and Technology; http://www.spaceandtech.com/digest/sd2000-22/sd2000-22-007.shtml, accessed August 27, 2005

Weston, Kay, comments in Advisory Committee for Commercial Remote Sensing (ACCRES), National Oceanic and Atmospheric Administration (NOAA), Open Session Meeting Summary [7th Meeting], September 13, 2005, 3; http://www.accres.noaa.gov/7thMeeting09-13-05.pdf, accessed September 13, 2007.

Weston, Kay. "NOAA Issues for Discussion" (briefing) in Advisory Committee for Commercial Remote Sensing (ACCRES), National Oceanic and Atmospheric Administration (NOAA), Open Session Meeting Summary [7th Meeting], September 13, 2005; http://www.accres.noaa.gov/7thMeeting09-13-05.pdf, accessed September 14, 2007.

Whalen, Mel. "The SeaWiFS Satellite," (Washington, DC: Galluadet University); http://clerccenter.gallaudet.edu/Mssd/MSSD-Science/satellites/seawiffy.html, accessed October 31, 2005.

White House, Fact Sheet: U.S. Commercial Remote Sensing Space Policy, Washington, DC, April 25, 2003; http://www.whitehouse.gov/news/releases/2003/05/20030513- 8.html, accessed June 11, 2006.

White House, "U.S. Commercial Remote Sensing Policy (Fact Sheet)," April 25, 2003, 2; http:////crsp.usgs.gov/pdgs/factsheet.pdf, accessed November 13, 2006.

White House, National Science and Technology Council, Fact Sheet: National Space Policy; http://www.ostp.gov/NSTC/html/fs/fs-5.html, accessed July 16, 2006.

White House, National Science and Technology Council, Fact Sheet: National Space Policy, September 19, 1996; http://www.ostp.gov/NSTC/html/fs/fs-5.html, accessed September 25, 2005.

White House, National Space Policy Directives and Executive Charter, NSPD-1, Washington, DC, November 2, 1989; http://www.au.af.mil/au/awc/awcgate/nspd1.htm, accessed June 3, 2006.

White House, "National Space Policy Review (Fact Sheet, NSPD-15)," June 23, 2002; http://www.ostp.gov/html/02_7_15_2.html, accessed November 10, 2006.

White House, Office of Science and Technology Policy and the National Security Council, Fact Sheet Regarding the Memorandum of Understanding Concerning the

Licensing of Private Remote Sensing Satellite Systems, Washington, DC, February 2, 2000.

White Office, Office of the Press Secretary, Foreign Access to Remote Sensing Space Capabilities, Statement and Fact Sheet [PDD-23], Washington, DC: March 10, 1994; Available on FAS website at: http://www.fas.org/irp/offDOCs/pdd23-2.htm, accessed October 15, 2005 and July 9, 2006.

White House, Presidential Directive/NSC-4, Washington, DC: October 10, 1978, 4.

White House, Presidential Directive/NSC-54, Washington, DC, November 16, 1979.

White House, Presidential Directive on National Space Policy, Washington, DC, February 11, 1988; http://www.fas.org/spp/military/docops/national/nspd1.htm, accessed June 20, 2006.

White House, U.S. Commercial Remote Sensing Policy: Fact Sheet, April 25, 2003; http://fas.org/irp/offDOCs/nspd/remsens.html, accessed November 30, 2005. Also available at http://www.fas.org/irp/offdocs/nspd/remsens.html, accessed June 25, 2006.

White House, U.S. Commercial Space Policy Guidelines, NSPD-3, Washington, DC, February 11, 1991; http://www.au.af.mil/au/awc/awcgate/nspd3.htm, accessed June 20, 2006.

Wilkening, Laurel L, statement in U.S. Congress, House of Representatives, Committee on Science, Subcommittee on Space, *The Future of the U.S. Space Industrial Base* (hearings), 103rd Congress, First Session (Washington, DC: U.S. Government Printing Office, 1993), 12.

Williamson, Ray A. "Remote Sensing Policy and the Development of Commercial Remote Sensing," in Baker, O'Connell, and Williamson, 37.

Willson, David L. "An Army view of neutrality in space: legal options for space negation (armed conflict and privately-owned satellites)," *Air Force Law Review* January 1, 2001; http://www.highbeam.com/library/DOCfree.asp?DOCID=1G1:75622166& ctrlInfo=Round18%3AMode18c%3ADOCG%3AResult&ao=, accessed October 26, 2005.

Wilson, J.D. "So Where's the High-Resolution Satellite Imagery," *GIS World* (GeoBusiness Watch), October 1988; http://www.geoplace.com/gw/1998/1098/1098bwtc.asp, accessed May 28, 2006.

_____, "With Friends Like This, Who Needs Enemies,?" *TBRNews*, October 17, 2005**;** http://www.tbrnews.org/Archives/a1912.htm, accessed April 2, 2006.

Withee, Gregory, opening remarks in Judith Carradeguas and Dan Sullivan, eds., *Commercial Remote Sensing Symposium • Proceedings* (May 13-15, 2003), Washington, DC: Institute of Global Environmental Strategies, 2004, 22.

Whitney, Gene, comments and repose to a question during the public session of a meeting of the Advisory Committee on Commercial Remote Sensing (ACCRES), NOAA, held in Washington, DC on March 10, 2006.

Woolsey, R. James, statement in U.S. House of Representatives, Committee on Science, Space, and Technology and Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era*, 22, 24.

Zimmerman, Peter D. "Remote Sensing Satellites and Superpower Relations," in Krepon, et. al., 35-43.

Zoominfo.com; http://www.zoominfo.com/Search/Personal.Detail.aspx?PersonalID=17593658&QueryID=cd533eec-d779-443d-9fdf-f2870a645f96, accessed December 8, 2007

Appendices A-K

Appendix A: Land Remote Sensing Commercialization Act of 1984 (Public Law 98-365)

Source: Society of Environmental Journalists; http://www.sej.org/foia/PL98-365.txt, accessed July 1, 2006.

Note: Minor typographical errors corrected.

LAND REMOTE-SENSING COMMERCIALIZATION ACT OF 1984
(July 17, 1984 PL 98-365)

Public Law 98-365

TITLE I: DECLARATION OF FINDINGS, PURPOSES, AND POLICIES

FINDINGS

SEC. 101. The Congress finds and declares that-

(1) 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;

(2) the Federal Government's experimental Landsat system has established the United States as the world leader in land remote-sensing technology;

(3) the national interest of the United States lies in maintaining international leadership in civil remote sensing and in broadly promoting the beneficial use of remote-sensing data;

(4) land remote sensing by the Government or private parties of the United States affects international commitments and policies and national security concerns of the United States;

(5) the broadest and most beneficial use of land remote-sensing data will result from maintaining a policy of nondiscriminatory access to data;

(6) competitive, market-driven private sector involvement in land remote sensing is in the national interest of the United States;

(7) use of land remote-sensing data has been inhibited by slow market development and by the lack of assurance of data continuity;

(8) the private sector, and in particular the "value-added" industry, is best suited to develop land remote-sensing data markets;

(9) there is doubt that the private sector alone can currently develop a total land remote-sensing system because of the high risk and large capital expenditure involved;

(10) cooperation between the Federal Government and private industry can help assure both data continuity and United States leadership;

(11) the time is now appropriate to initiate such cooperation with phased transition to a fully commercial system;

(12) such cooperation should be structured to involve the minimum practicable amount of support and regulation by Federal Government and the maximum practicable amount of competition by the private sector, while assuring continuous availability to the Federal Government of land remote-sensing data;

(13) certain Government oversight must be maintained to assure that private sector activities are in the national interest and that the international commitments and policies of the United States are honored; and

(14) there is no compelling reason to commercialize meteorological satellites at this time.

PURPOSES

SEC. 102. The purposes of this Act are to-

(1) guide the Federal Government in achieving proper involvement of the private sector by providing a framework for phased commercialization of land remote sensing and by assuring continuous data availability to the Federal Government;

(2) maintain the United States worldwide leadership in civil remote sensing, preserve its national security, and fulfill its international obligations;

(3) minimize the duration and amount of further Federal investment necessary to assure data continuity while achieving commercialization of civil land remote sensing;

(4) provide for a comprehensive civilian program of research, development, and demonstration to enhance both the United States capabilities for remote sensing from space and the application and utilization of such capabilities; and

(5) prohibit commercialization of meteorological satellites at this time.

POLICIES

SEC. 103.

(a) It shall be the policy of the United States to preserve its right to acquire and disseminate unenhanced remote-sensing data.

(b) It shall be the policy of the United States that civilian unenhanced remote-sensing data be made available to all potential users on a nondiscriminatory basis and in a manner consistent with applicable anti-trust laws.

(c) It shall be the policy of the United States both to commercialize those remote-sensing space systems that properly lend themselves to private sector operation and to avoid competition by the Government with such commercial operations, while continuing to preserve our national security, to honor our international obligations, and to retain in the Government those remote-sensing functions that are essentially of a public service nature.

DEFINITIONS

SEC. 104. For purposes of this Act:

(1) The term "Landsat system" means Landsats 1, 2, 3, 4, and 5, and any related ground equipment, systems, and facilities, and any successor civil land remote-sensing space systems operated by the United States Government prior to the commencement of the six-year period described in title III.

(2) The term "Secretary" means the Secretary of Commerce.

(3)

(A) The term "nondiscriminatory basis" means without preference, bias, or any other special arrangement (except on the basis of national security concerns pursuant to section 607) regarding delivery, format, financing, or technical considerations which would favor one buyer or class of buyers over another.

(B) The sale of data is made on a nondiscriminatory basis only if

(i) any offer to sell or deliver data is published in advance in such manner as will ensure that the offer is equally available to all prospective buyers;

(ii) the system operator has not established or changed any price, policy, procedure, or other term or condition in a manner which gives one buyer or class of buyer de facto favored access to data;

(iii) the system operator does not make unenhanced data available to any purchaser on an exclusive basis; and

(iv) in a case where a system operator offers volume discounts, such discounts are no greater than the demonstrable reductions in the cost of volume sales. The sale of data on a nondiscriminatory basis does not preclude the system operator from offering discounts other than volume discounts to the extent that such discounts are consistent with the provisions of this paragraph.

(C) The sale of data on a nondiscriminatory basis does not require (i) that a system operator disclose names of buyers or their purchases; (ii) that a system operator maintain all, or any particular subset of, data in a working inventory; of (iii) that a system operator expend equal effort in developing all segments of a market.

(4) The term "unenhanced data" means unprocessed or minimally processed signals or film products collected from civil remote sensing space systems. Such minimal processing may include rectification of distortions, registration with respect to features of the Earth, and calibration of spectral response. Such minimal processing does not include conclusions, manipulations, or calculations derived from such signals or film products or combination of the signals or film products with other data or information.

(5) The term "system operator" means a contractor under title II or title III or a license holder under title IV.

TITLE II: OPERATION AND DATA MARKETING OF LANDSAT SYSTEM

OPERATION

SEC. 201.

(a) The Secretary shall be responsible for-

(1) the Landsat system, including the orbit, operation, and disposition of Landsats 1, 2, 3, 4, and 5; and

(2) provision of data to foreign ground stations under the terms of agreements between the United States Government and nations that operate such ground stations which are in force on the date of commencement of the contract awarded pursuant to this title.

(b) The provisions of this section shall not affect the Secretary's authority to contract for the operation of part or all of the Landsat system, so long as the United States Government retains-

(1) ownership of such system;

(2) ownership of the unenhanced data;

(3) authority to make decisions concerning operation of the system.

CONTRACT FOR MARKETING OF UNENHANCED DATA

SEC. 202.

(a) In accordance with the requirements of this title, the Secretary, by means of a competitive process and to the extent provided in advance by appropriation Acts, shall contract with a United States private sector party (as defined by the Secretary) for the marketing of unenhanced data collected by the Landsat system. Any such contract-

(1) shall provide that the contractor set the prices of unenhanced data;

(2) may provide for financial arrangements between the Secretary and the contractor including fees for operating the system, payments by the contractor as an initial fee or as a percentage of sales receipts, or other such considerations;

(3) shall provide that the contractor will offer to sell and deliver unenhanced data to all potential buyers on a nondiscriminatory basis;

(4) shall provide that the contractor pay to the U.S. Government the full purchase price of any unenhanced data that the contractor elects to utilize for purposes other than sale;

(5) shall be entered into by the Secretary only if the Secretary has determined that such contract is likely to result in net cost savings for the U.S. Government; and (6) may be reawarded competitively after the practical demise of the space segment of the Landsat system, as determined by the Secretary.

(b) Any contract authorized by subsection (a) may specify that the contractor use, and, at his own expense, maintain, repair, or modify, such elements of the Landsat system as the contractor finds necessary for commercial operations.

(c) Any decision or proposed decision by the Secretary to enter into any such contract shall be transmitted to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Science and Technology of the House of Representatives for their review. No such decision or proposed decision shall be implemented unless

(A) a period of 30 calendar days has passed after the receipt by each such committee of such transmittal, or

(B) each such committee before the expiration of such period has agreed to transmit and has transmitted to the Secretary written notice to the effect that such committee has no objection to the decision or proposed decision. As part of the transmittal, the Secretary shall include information on the terms of the contract described in subsection (a).

(d) In defining "United States private sector party" for purposes of this Act, the Secretary may take into account the citizenship of key personnel, location of assets, foreign ownership, control, influence, and other such factors.

CONDITIONS OF COMPETITION FOR CONTRACT

SEC. 203.

(a) The Secretary shall, as part of the advertisement for the competition for the contract authorized by section 202, identify and publish the international obligations, national security concerns (with appropriate protection of sensitive information), domestic legal considerations, and any other standards or conditions which a private contractor shall be required to meet.

(b) In selecting a contractor under this title, the Secretary shall consider-

(1) ability to market aggressively unenhanced data;

(2) the best overall financial return to the Government, including the potential cost savings to the Government that are likely to result from the contract;

(3) ability to meet the obligations, concerns, considerations, standards, and conditions identified under subsection (a);

(4) technical competence, including the ability to assure continuous and timely delivery of data from the Landsat system;

(5) ability to effect a smooth transition with the contractor selected under title III; and

(6) such other factors as the Secretary deems appropriate and relevant.

(c) If, as a result of the competitive process required by section 202(a), the Secretary receives no proposal which is acceptable under the provisions of this title, the Secretary shall so certify and fully report such finding to the Congress. As soon as practicable but not later than 30 days after so certifying and reporting the Secretary shall reopen the competitive process. The period for the subsequent competitive process shall not exceed 120 days. If, after such subsequent competitive process, the Secretary receives no proposal which is acceptable under the provisions of this title, the Secretary shall so certify and fully report such finding to the Congress. In the event that no acceptable proposal is received, the Secretary shall continue to market data from the Landsat system.

(d) A contract awarded under section 202 may, in the discretion of the Secretary, be combined with the contract required by title III, pursuant to section 304(b).

SALE OF DATA

SEC. 204.

(a) After the date of the commencement of the contract described in section 202(a), the contractor shall be entitled to revenues from sales of copies of data from the Landsat system, subject to the conditions specified in sections 601 and 602.

(b) The contractor may continue to market data previously generated by the Landsat system after the demise of the space segment of that system.

FOREIGN GROUND STATIONS

SEC. 205.

(a) The contract under this title shall provide that the contractor shall act as the agent of the Secretary by continuing to supply unenhanced data to foreign ground stations for the life, and according to the terms, of those agreements between the United States Government and such foreign ground stations that are in force on the date of the commencement of the contract.

(b) Upon the expiration of such agreements, or in the case of foreign ground stations that have no agreement with the United States on the date of commencement of the contract, the contract shall provide-(1) that unenhanced data from the Landsat system shall be made available to foreign ground stations only by the contractor; and (2) that such data shall be made available on a nondiscriminatory basis.

TITLE III: PROVISION OF DATA CONTINUITY AFTER THE LANDSAT SYSTEM

PURPOSES AND DEFINITION

SEC. 301.

(a) It is the purpose of this title-

(1) to provide, in an orderly manner and with minimal risk, for a transition from Government operation to private, commercial operation of civil land remote-sensing systems; and

(2) to provide data continuity for six years after the practical demise of the space segment of the Landsat system.

(b) For purposes of this title, the term "data continuity" means the continued availability of unenhanced data-

(1) including data which are from the point of view of a data user-

(A) functionally equivalent to the multi-spectral data generated by the Landsat 1 and 2 satellites; and

(B) compatible with such data and with equipment used to receive and process such data; and

(2) at an annual volume at least equal to the Federal usage during fiscal year 1983.

(c) Data continuity may be provided using whatever technologies are available.

DATA CONTINUITY AND AVAILABILITY

SEC. 302.

The Secretary shall solicit proposals from United States private sector parties (as defined by the Secretary pursuant to section 202) for a contract for the development and operation of a remote-sensing space system capable of providing data continuity for a period of six years and for marketing unenhanced data in accordance with the provisions of sections 601 and 602. Such proposals, at a minimum, shall specify-

(1) the quantities and qualities of unenhanced data expected from the system;

(2) the projected date upon which operations could begin;

(3) the number of satellites to be constructed and their expected lifetimes;

(4) any need for Federal funding to develop the system;

(5) any percentage of sales receipts or other returns offered to the Federal Government;

(6) plans for expanding the market for land remote-sensing data; and

(7) the proposed procedures for meeting the national security concerns and international obligations of the United States in accordance with section 607.

AWARDING OF THE CONTRACT

Sec. 303.

(a)

(1) In accordance with the requirements of this title, the Secretary shall evaluate the proposals described in section 302 and, by means of a competitive process and to the extent provided in advance by appropriation Acts, shall contract with a United States private sector party for the capability of providing data continuity for a period of six years and for marketing unenhanced data.

(2) Before commencing space operations the contractor shall obtain a license under title IV.

(b) As part of the evaluation described in subsection (a), the Secretary shall analyze the expected outcome of each proposal in terms of –

(1) the net cost to the Federal Government of developing the recommended system;

(2) the technical competence and financial condition of the contractor;

(3) the availability of such data after the expected termination of the Landsat system;

(4) the quantities and qualities of data to be generated by the recommended system;

(5) the contractor's ability to supplement the requirement for data continuity by adding, at the contractor's expense, remote-sensing, capabilities which maintain United States leadership in remote-sensing;

(6) the potential to expand the market for data;

(7) expected returns to the Federal Government based on any percentage of data sales or other such financial consideration offered to the Federal Government in accordance with section 305;

(8) the commercial viability of the proposal;

(9) the proposed procedures for satisfying the national security concerns and international obligations of the United States;

(10)the contractor's ability to effect a smooth transition with any contractor selected under title TT; and (11)such other factors as the Secretary deems appropriate and relevant.

(c) Any decision or proposed decision by the Secretary to enter into any such contract shall be transmitted to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Science and technology of the House of Representatives for their review. No such decision or proposed decision shall be implemented unless

(1) a period of 30 calendar days has passed after the receipt by each such committee of such transmittal, or

(2) each such committee before the expiration of such period has agreed to transmit and has transmitted to the Secretary written notice to the effect that such committee has no objection to the decision or proposed decision. As part of the transmittal, the Secretary shall include the information specified in subsection (a).

(d) If, as a result of the competitive process required by this section, the Secretary receives no proposal which is acceptable under the provisions of this title, the Secretary shall so certify and fully report such finding to the Congress. As soon as practicable but not later than 30 days after so certifying and reporting, the Secretary shall reopen the competitive process. The period for the subsequent competitive process shall not exceed 180 days. If, after such subsequent competitive process, the Secretary receives no proposal which is acceptable under the provisions of this title, the Secretary shall so certify and fully report such finding to the Congress. Not earlier than 90 days after such certification and report, the Secretary may assure data continuity by procurement and operation by the Federal Government of the necessary systems, to the extent provided in advance by appropriation Acts.

TERMS OF CONTRACT

Sec. 304.

(a)

(1) shall be entered into as soon as practicable, allowing for the competitive procurement process required by this title;

(2) shall, in accordance with criteria determined and published by the Secretary, reason ably assure data continuity for a period of six years, beginning as soon as practicable in order to minimize any interruption of data availability;

(3) shall provide that the contractor will offer to sell and deliver unenhanced data to all potential buyers on a nondiscriminatory basis;

(4) shall not provide a guarantee of data purchases from the contractor by the Federal Government;

(5) may provide that the contractor utilize, on a space-available basis, a civilian United States Government satellite or vehicle as a platform for a civil land remote-sensing space system, if-

(A) the contractor agrees to reimburse the Government immediately for all related costs incurred with respect to such utilization, including a reasonable and proportionate share of fixed, platform, data transmission, and launch costs; and

(B) such utilization would not interfere with or otherwise compromise intended civilian Government missions, as determined by the agency responsible for the civilian platform; and

(b)

(1) Without regard to whether any contract entered into under this title is combined with a contract under title II, the Secretary shall promptly determine whether the contract entered into under this title reasonably effectuates the proposes and policies of title II. Such determination shall be submitted to the President and the Congress, together with a full statement of the basis for such determination.

(2) If the Secretary determination that such contract does not reasonably effectuate the requirements of title II, the provisions of such title to the extent provided in advance in appropriations acts.

MARKETING

Sec. 305.

(a) In order to promote aggressive marketing of land remote-sensing data, any contract entered into pursuant to this title may provide that the percentage of sales paid by the contractor to the Federal Government shall decrease according to stipulated increases in sales levels.

(b) After the six-year period described in section 304 (a) (2), the contractor may continue to sell data. If licensed under title IV; the contractor may continue to operate a civil remote-sensing space system.

REPORT

Sec. 306.

Two year after the date of the commencement of the six-year period described in section 304 (a) (2), the Secretary shall report to the President and to the Congress on the progress of the transition to fully private financing, ownership, and operation of remote-sensing space systems, together with any recommendations for actions, including actions necessary to ensure United States leadership in civilian land remote-sensing from space.

TERMINATION OF AUTHORITY

Sec. 307.

The authority granted to the Secretary by this title shall terminate 10 years after the date of enactment of this Act.

TITLE IV: LICENSING OF PRIVATE REMOTE-SENSING SPACE SYSTEMS

GENERAL AUTHORITY

Sec. 410.

(a)

(1) In consultation with other appropriate Federal agencies, the Secretary is authorized to license private sector parties to operate private remote-sensing space systems for such period as the Secretary may specify and in accordance with the provisions of this title.

(2) In the case of a private space system that is used for remote-sensing and other purposes, the authority of the Secretary under this title shall be limited only to the remote-sensing operations of such space system.

(b) No license shall be granted by the Secretary unless the Secretary determines in writing that the applicant will comply with the requirements of this Act, and any applicable international obligations and national security concerns of the United States.

(c) The Secretary shall review any application and make a determination thereon within 120 days of the receipt of such application. If final action has not occurred within such time, the Secretary shall inform the applicant of any pending issues and of actions required to resolve them.

(d) the Secretary shall not deny such license in order to protect any existing licensee from competition.

CONDITIONS FOR OPERATION

Sec. 401.

(a) No person who is subject to the jurisdiction or control of the United States may, directly or through any subsidiary or affiliate, operate any private remote-sensing space system without a license pursuant to section 401.

(b) Any license issued pursuant to this title shall specify, at a minimum, that the licensee shall comply with all of the requirements of this Act and shall-

(1) operate the system in such manner as to preserve and promote the national security of the United States and to observe and implement the international obligations of the United States in accordance with section 607;

(2) make unenhanced data available to all potential users on a nondiscriminatory basis;

(3) upon termination of operations under the license, make disposition of any satellites in space in a manner satisfactory to the President;

(4) promptly make available all unenhanced data which the Secretary may request pursuant to section 602;

(5) furnish the Secretary with complete orbit and data collection characteristics of the system, obtain advance approval of any intended deviation from such characteristics, and inform the Secretary immediately of any unintended deviation;

(6) notify the Secretary of any agreement the licensee intends to enter with a foreign nation, entity or consortium involving foreign nations or records;

(7) permit the inspection by the Secretary of the licensee's equipment, facilities, and financial records;

(8) surrender the license and terminate operations upon notification by the Secretary pursuant to section 403 (a) (1); and

(9)

(A) notify the Secretary of any "value added" activities (as defined by the Secretary by regulation) that will be conducted by the licensee or by a subsidiary or affiliate; and

(B) if such activities are to be conducted, provide the Secretary with a plan for compliance with the provisions of this Act concerning nondiscriminatory access.

ADMINISTRATIVE AUTHORITY OF THE SECRETARY

Sec. 403.

(a) In order to carry out the responsibilities specified in this title, the Secretary may-

(1) grant, terminate, modify, condition, transfer, or suspend licenses under this title, and upon notification of the licensee may terminate licensed operations on an immediate basis, if the Secretary determines that the licensee has substantially failed to comply with any provision of this Act, with any terms, conditions, or restrictions of such license, or with any international obligations or national security concerns of the United States;

(2) inspect the equipment, facilities, or financial records of any licensee under this title;

(3) provide penalties for noncompliance with the requirements of licenses or regulations issued under this title, including civil penalties not to exceed $10,000 (each day of operation in violation of such licenses or regulations constituting a separate violation);

(4) compromise, modify, or remit any such civil penalty;

(5) issue subpoenas for any materials, documents, or records, or for the attendance and testimony of witnesses for the purpose of conducting a hearing under this section;

(6) seize any object, record, or report where there is probable cause to believe that such object, record, or report was used, is being used, or is likely to be used in violation of this Act or the requirements of a license or regulation issued thereunder; and

(7) make investigations and inquiries and administer to or take from any person an oath, affirmation, or affidavit concerning any matter relating to the enforcement of this Act.

(b) Any applicant or licensee who makes a timely request for review of an adverse action pursuant to subsections (a) (1), (a) (3), or (a) (6) shall be entitled to adjudication by the Secretary on the record after an opportunity for an agency hearing with respect to such adverse action. Any final action by the Secretary under this subsection shall be subject to judicial review under chapter 7 of title 5, United States Code.

REGULATORY AUTHORITY OF THE SECRETARY

Sec. 404.

The Secretary may issue regulations to carry out the provisions of this title. Such regulations shall be promulgated only after public notice and comment in accordance with the provisions of section 553 of title 5, United States Code.

AGENCY ACTIVITIES

Sec. 405.

(a) A private sector party may apply for a license to operate a private remote-sensing space system which utilizes, on a space available basis, a civilian United States Government satellite or vehicle as a platform for such system. The Secretary, pursuant to the authorities of this title, may license such system if it meets all conditions of this title and-

(1) the system operator agrees to reimburse the Government immediately for all related costs incurred with respect to such utilization, including a reasonable and proportionate share of fixed, platform, data transmission, and launch costs; and (2) such utilization would not interfere with or otherwise compromise intended civilian Government missions, as determined by the agency responsible for such civilian platform.

(b) The Secretary may offer assistance to private sector parties in finding appropriate opportunities for such utilization.

(c) To the extent provided in advance by appropriation Acts, any Federal agency may enter into agreements for such utilization if such agreements are consistent with such agency's mission and statutory authority, and if such remote-sensing space system is licensed by the Secretary before commencing operation.

(d) The provisions of this section do not apply to activities carried out under title V.

(e) Nothing in this title shall affect the authority of the Federal Communications Commission pursuant to the Communications Act of 1934, as amended (47 U.S.C. 151 et seq.).

TERMINATION

Sec. 406.

If, five years after the expiration of the six-year period described in section 304 (aY2), no private sector party has been licensed and continued in operation under the provisions of this title, the authority of this title shall terminate.

TITLE V: RESEARCH AND DEVELOPMENT

CONTINUED FEDERAL RESEARCH AND DEVELOPMENT

Sec. 501.

(a)

(1) The Administrator of the National Aeronautics and Space Administration is directed to continue and to enhance such Administration's programs of remote-sensing research and development.

(2) The administrator is authorized and encouraged to-

(A) conduct experimental space remote-sensing programs (including applications demonstration programs and basic research at universities);

(B) develop remote-sensing technologies and techniques, including those needed for monitoring the Earth and its environment; and

(C) conduct such research and development in cooperation with other Federal agencies and with public and private research entities (including private industry, universities, State and local governments, foreign governments, and international organizations) and to enter into arrangements (including joint ventures) which will foster such cooperation.

(b)

(1) The Secretary is directed to conduct a continuing program of-

(A) research in applications of remote-sensing;

(B) monitoring of the Earth and its environment; and

(C) development of technology for such monitoring.

(2) Such program may include support of basic research at universities and demonstrations of applications.

(3) Encouraged to conduct such research, monitoring, and development in cooperation with other Federal agencies and with public and private research entities (including private industry, universities, State and local governments, foreign governments, and international organizations) and to enter into arrangements (including joint ventures) which will foster such cooperation.

(c)

(1) In order to enhance the United States ability to manage and utilize its renewable and nonrenewable resources, the Secretary of Agriculture and the Secretary of the interior are

authorized and encouraged to conduct programs of research and development in the applications of remote-sensing using funds appropriated for such purposes.

(2) Such programs may include basic research at universities, demonstrations of applications, and cooperative activities involving other government agencies, private sector parties, and foreign and international organizations.

(d) Other Federal agencies are authorized and encouraged to conduct research and development on the use of remote-sensing in fulfillment of their authorized missions, using funds appropriated for such purposes.

(e) The Secretary and the Administrator or the National Aeronautics and Space Administration shall, within one year after the date of enactment of this Act and biennially thereafter, jointly develop and transmit to the Congress a report which includes

(1) a unified national plan for remote-sensing research and development applied to the Earth and its atmosphere;

(2) a compilation of progress in the relevant ongoing research and development activities of the Federal agencies; and

(3) an assessment of the state of our knowledge of the Earth and its atmosphere, the needs for additional research (including research related to operational Federal remote-sensing space programs), and opportunities available for further progress.

USE OF EXPERIMENTAL DATA

Sec. 502.

Data gathered in Federal experimental remote Sensing space programs may be used in related research and development programs funded by the Federal Government (including applications programs) and cooperative research programs, but not commercial uses or in competition with private sector activities, except pursuant to section 503.

SALE OF EXPERIMENTAL DATA

Sec. 503.

Data gathered in Federal experimental remote-sensing space programs may be sold en bloc through a competitive process (consistent with national security interest and international obligations of the United States and in accordance with section 607) to any United States entity which will market the data on nondiscriminatory basis.

TITLE VI: GENERAL PROVISIONS

NONDISCRIMINATORY DATA AVAILABILITY

Sec. 601.

(a) Any unenhanced data generated by any system operator under the provisions of this Act shall be made available to all users on a nondiscriminatory basis in accordance with the requirements of this Act.

Note: [Either paragraph (b) may have been inadvertently omitted when the text was transcribed for source website, or the next paragraph (i.e., (c)) was a typographical error and should have been (b)]

(c) Any system operator shall make publicly available the prices, policies procedures, and other terms and conditions (but, in accordance with section 104 (3) (C), not necessarily the names of buyers or their purchases) upon which the operator will sell such data.

ARCHIVING OF DATA

Sec. 602.

(a) It is in the public interest for the United States Government-

(1) to maintain an archive of land remote-sensing data for historical, scientific, and technical purposes, including long-term global environmental monitoring;

(2) to control the content and scope of the archive; and

(3) to assure the quality, integrity, and continuity of the archive.

(b) The Secretary shall provide for long-term storage, maintenance, and upgrading of a basic, global, land remote-sensing data set (hereinafter referred to as the "bas data set") and shall follow reasonable archival practices to assure proper storage and preservation of the basic data set and timely access for parties requesting data. The basic data set which the Secretary assembles the Government archive shall remain distinct from any inventory of data which system operator may maintain for sales an for other purposes.

(c) In determining the initial content of, or in upgrading, the basic data set, the Secretary shall-

(1) use as a baseline the data archived or the date of enactment of this Act;

(2) take into account future technical am scientific developments and needs;

(3) consult with and seek the advice of users and producers of remote-sensing data and data products;

(4) consider the need for data which may be duplicative in terms of geographical coverage but which differ in terms of season. Spectral bands, resolution, or other relevant factors;

(5) include, as the Secretary considers appropriate, unenhanced data generated either by the Landsat system, pursuant to title III or by licensees under title IV;

(6) include, as the Secretary considers appropriate, data collected by foreign ground stations or by foreign remote-sensing space systems; and

(7) ensure that the content of the archive is developed in accordance with section 607.

(d) Subject to the availability of appropriations, the Secretary shall request data needed for the basis data set and pay to the providing system operator reasonable costs for reproduction and transmission. A system operator shall promptly make requested data available in a form suitable for processing for archiving.

(e) Any system operator shall have the exclusive right to sell all data that the operator provides to the United States remote-sensing data archive for a period to be determined by the Secretary but not to exceed ten years from the date the data are sensed. In the case of data generated from the Landsat system prior to the implementation of the contract described in section 202(a), any contractor selected pursuant to section 202 shall have the exclusive right to market such data on behalf of the United States Government for the duration of such contract. A system operator may relinquish the exclusive right and consent to distribution from the archive before the period of exclusive right has expired by terminating the offer to sell particular data.

(f) After the expiration of such exclusive right to sell, or after relinquishment of such right, the data provided to the Unite States remote-sensing data archive shall be in the public domain and shall be made available to requesting parties by the Secretary at prices reflecting reasonable costs of reproduction and transmittal.

(g) In carrying out the functions of this section, the Secretary shall, to the extent practicable and as provided in advance by appropriation Acts, use existing Government facilities.

NONREPRODUCTION

Sec. 603.

Unenhanced data distributed by any system operator under the provisions of this Act may be sold on the condition that such data will not be reproduced or disseminated by the purchaser.

REIMBURSEMENT FOR ASSISTANCE

Sec. 604.

The Administrator of the National Aeronautics and Space Administration, the Secretary of Defense and the heads of other Federal agencies may provide assistance to system operators under the provisions of this Act. Substantial assistance shall be reimbursed by the operator, except as otherwise provided by law.

ACQUISITION OF EQUIPMENT

Sec. 605.

The Secretary may, by means of a competitive process, allow a licensee under title IV or any other private party to buy, lease, or otherwise acquire the use of equipment from the Landsat system, when such equipment is no longer needed for the operation of such system or for the sale of data from such system. Officials of other Federal civilian agencies are authorized and encouraged to cooperate with the Secretary in carrying out the provisions of this section.

RADIO FREQUENCY ALLOCATION

Sec. 606.

(a) Within 30 days after the date of enactment of this Act, the President (or the President's delegee, if any, with authority over the assignment of frequencies to radio stations or classes of radio stations operated by the United States) shall make available for non-governmental use spectrum presently allocated to government use, for use by United States Landsat and commercial remote-sensing space systems. The spectrum to be so made available shall conform to any applicable international radio or wire treaty or convention, or regulations annexed thereto. Within 90 days thereafter, the Federal Communications Commission shall utilize appropriate procedures to authorize the use of such spectrum for non-governmental use. Nothing in this section shall preclude the ability of the Commission to allocate additional spectrum to commercial land remote-sensing space satellite system use.

(b) To the extent required by the Communications Act of 1934, as amended (47 U.S.C. 151 et. seq.), an application shall be filed with the Federal Communications Commission for any radio facilities involved with the commercial remote-sensing space system.

(c) It is the intent of Congress that the Federal Communications Commission complete the radio licensing process under the Communications Act of 1934, as amended (47 US.C.151 et. seq.), upon the application of any private sector party or consortium operator of any commercial land remote-sensing space system subject to this Act, within 120 days of the receipt of an application for such licensing. If final action has not occurred within 120 days of the receipt of such an application, the Federal Communications Commission shall inform the applicant of any pending issues and of actions required to resolve them.

(d) Authority shall not be required from the Federal Communications Commission for the development and construction of any United States land remote-sensing space system (or component thereof), other than radio transmitting facilities or components, while any licensing determination is being made.

(e) Frequency allocations made pursuant to this section by the Federal Communications Commission shall be consistent with international obligations and with the public interest.

CONSULTATION

Sec. 607.

(a) The Secretary shall consult with the Secretary of Defense on all matters under this Act affecting national security. The Secretary of Defense shall be responsible for determining those conditions, consistent with this Act, necessary to meet national security concerns of the United States and for notifying the Secretary promptly of such conditions.

(b)

(1) The Secretary shall consult with the Secretary of State on all matters under this Act affecting international obligations. The Secretary of State shall be responsible for determining those conditions, consistent with this Act, necessary to meet international obligations and policies of the United States and for notifying the Secretary promptly of such conditions.

(2) Appropriate Federal agencies are authorized and encouraged to provide remote-sensing data, technology, and training to developing nations as a component of programs of international aid.

(3) The Secretary of State shall promptly report to the Secretary any instances outside the United States of discriminatory distribution of data.

(c) If, as a result of technical modifications imposed on a system operator on the basis of national security concerns, the Secretary, in consultation with the Secretary of Defense or with other Federal agencies, determines that additional costs will be incurred by the system operator, or that past development costs (including the cost of capital) will not be recovered by the system operator, the Secretary may require the agency or agencies requesting such technical modifications to reimburse the system operator for such additional or development costs, but not for anticipated profits. Reimbursements may cover costs associated with required changes in system performance, but not costs ordinarily associated with doing business abroad.

AMENDMENT TO NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AUTHORIZATION, 1983

Sec. 608.

Subsection (a) of section 201 of the National Aeronautics and Space Administration Authorization Act, 1983 (Public Law 97-324: 96 Stat.1601) is amended to read as follows; "(a) The Secretary of Commerce is authorized to plan and provide for the management and operation of civil remote-sensing space systems, which may include the Landsat 4 and 5 satellites and associated ground system equipment transferred from the National Aeronautics and Space Administration; to provide for user fees: and to plan for the transfer of the operation of civil remote-sensing space systems to the private sector when in the national interest.

AUTHORIZATION OF APPROPRIATIONS

Sec. 609.

(a) There are authorized to be appropriated to the Secretary $75,000,000 for fiscal year 1985 for the purpose of carrying out the provisions of this Act. Such sums shall remain available until expended, but shall not become available until the time periods specified in sections 202 (c) and 303 (c) have expired.

(b) The authorization provided for under subsection (a) shall be in addition to moneys authorized pursuant to title II of the National Aeronautics and Space Administration Authorization Act. 1983.

TITLE VII: PROHIBITION OF COMMERCIALIZATION OF WEATHER SATELLITES

PROHIBITION

Sec. 701.

Neither the President nor any other official of the Government shall make any effort to lease, sell, or transfer to the private sector, commercialize, or in any way dismantle any portion of the weather satellite systems operated by the Department of Commerce or any successor agency.

FUTURE CONSIDERATIONS

Sec. 702.

Regardless of any change in circumstances subsequent to the enactment of this Act, even if such change makes it appear to be in the national interest to commercialize weather satellites, neither the President nor any official shall take any action prohibited by section 701 unless this title has first been repealed.

Appendix B: Land Remote Sensing Policy Act of 1992 (Public Law 102-555)

Source: National Aeronautics and Space Administration; http://geo.arc.nasa.gov/sge/landsat/15USCch82.html, accessed July 9, 2006.

Note: Only Subchapter II of the Act is included here, since it is the only part that deals exclusively with commercial remote sensing.

SUBCHAPTER II - LICENSING OF PRIVATE REMOTE SENSING SPACE SYSTEMS

Sec. 5621. General licensing authority

a. Licensing authority of Secretary
   1. In consultation with other appropriate United States Government agencies, the Secretary is authorized to license private sector parties to operate private remote sensing space systems for such period as the Secretary may specify and in accordance with the provisions of this subchapter.
   2. In the case of a private space system that is used for remote sensing and other purposes, the authority of the Secretary under this subchapter shall be limited only to the remote sensing operations of such space system.

b. Compliance with law, regulations, international obligations, and national security

   No license shall be granted by the Secretary unless the Secretary determines in writing that the applicant will comply with the requirements of this chapter, any regulations issued pursuant to this chapter, and any applicable international obligations and national security concerns of the United States.

c. Deadline for action on application

   The Secretary shall review any application and make a determination thereon within 120 days of the receipt of such application. If final action has not occurred within such time, the Secretary shall inform the applicant of any pending issues and of actions required to resolve them.

d. Improper basis for denial

   The Secretary shall not deny such license in order to protect any existing licensee from competition.

e. Requirement to provide unenhanced data
   1. The Secretary, in consultation with other appropriate United States Government agencies and pursuant to paragraph (2), shall designate in a license issued pursuant to this subchapter any unenhanced data required to be provided by the licensee under section 5622(b)(3) of this title.
   2. The Secretary shall make a designation under paragraph (1) after determining that -

A. such data are generated by a system for which all or a substantial part of the development, fabrication, launch, or operations costs have been or will be directly funded by the United States Government; or
B. it is in the interest of the United States to require such data to be provided by the licensee consistent with section 5622(b)(3) of this title, after considering the impact on the licensee and the importance of promoting widespread access to remote sensing data from United States and foreign systems.

3. A designation made by the Secretary under paragraph (1) shall not be inconsistent with any contract or other arrangement entered into between a United States Government agency and the licensee.

Sec. 5622. Conditions for operation

a. License required for operation

   No person who is subject to the jurisdiction or control of the United States may, directly or through any subsidiary or affiliate, operate any private remote sensing space system without a license pursuant to section 5621 of this title.

b. Licensing requirements

   Any license issued pursuant to this subchapter shall specify that the licensee shall comply with all of the requirements of this chapter and shall -

   1. operate the system in such manner as to preserve the national security of the United States and to observe the international obligations of the United States in accordance with section 5656 of this title;
   2. make available to the government of any country (including the United States) unenhanced data collected by the system concerning the territory under the jurisdiction of such government as soon as such data are available and on reasonable terms and conditions;
   3. make unenhanced data designated by the Secretary in the license pursuant to section 5621(e) of this title available in accordance with section 5651 of this title;
   4. upon termination of operations under the license, make disposition of any satellites in space in a manner satisfactory to the President;
   5. furnish the Secretary with complete orbit and data collection characteristics of the system, and inform the Secretary immediately of any deviation; and
   6. notify the Secretary of any agreement the licensee intends to enter with a foreign nation, entity, or consortium involving foreign nations or entities.

c. Additional licensing requirements for Landsat 6 contractor In addition to the requirements of paragraph [FOOTNOTE: So in original. Probably should be 'subsection'.] (b), any license issued pursuant to this subchapter to the Landsat 6 contractor shall specify that the Landsat 6 contractor shall -

1. notify the Secretary of any value added activities (as defined by the Secretary by regulation) that will be conducted by the Landsat 6 contractor or by a subsidiary or affiliate; and
2. if such activities are to be conducted, provide the Secretary with a plan for compliance with section 5651 of this title.

Sec. 5623. Administrative authority of Secretary

a. Functions

   In order to carry out the responsibilities specified in this subchapter, the Secretary may -

   1. grant, condition, or transfer licenses under this chapter;
   2. seek an order of injunction or similar judicial determination from a United States District Court with personal jurisdiction over the licensee to terminate, modify, or suspend licenses under this subchapter and to terminate licensed operations on an immediate basis, if the Secretary determines that the licensee has substantially failed to comply with any provisions of this chapter, with any terms, conditions, or restrictions of such license, or with any international obligations or national security concerns of the United States.
   3. provide penalties for noncompliance with the requirements of licenses or regulations issued under this subchapter, including civil penalties not to exceed $10,000 (each day of operation in violation of such licenses or regulations constituting a separate violation);
   4. compromise, modify, or remit any such civil penalty;
   5. issue subpoenas for any materials, documents, or records, or for the attendance and testimony of witnesses for the purpose of conducting a hearing under this section;
   6. seize any object, record, or report pursuant to a warrant from a magistrate based on a showing of probable cause to believe that such object, record, or report was used, is being used, or is likely to be used in violation of this chapter or the requirements of a license or regulation issued thereunder; and
   7. make investigations and inquiries and administer to or take from any person an oath, affirmation, or affidavit concerning any matter relating to the enforcement of this chapter.

b. Review of agency action

   Any applicant or licensee who makes a timely request for review of an adverse action pursuant to subsection (a)(1), (a)(3), (a)(5), or (a)(6) of this section shall be entitled to adjudication by the Secretary on the record after an opportunity for any agency hearing with respect to such adverse action. Any final action by the Secretary under this subsection shall be subject to judicial review under chapter 7 of title 5.

Sec. 5624. Regulatory authority of Secretary

The Secretary may issue regulations to carry out this subchapter. Such regulations shall be promulgated only after public notice and comment in accordance with the provisions of section 553 of title 5.

Sec. 5625. Agency activities

a. License application and issuance

   A private sector party may apply for a license to operate a private remote sensing space system which utilizes, on a space-available basis, a civilian United States Government satellite or vehicle as a platform for such system. The Secretary, pursuant to this subchapter, may license such system if it meets all conditions of this subchapter and -

   1. the system operator agrees to reimburse the Government in a timely manner for all related costs incurred with respect to such utilization, including a reasonable and proportionate share of fixed, platform, data transmission, and launch costs; and
   2. such utilization would not interfere with or otherwise compromise intended civilian Government missions, as determined by the agency responsible for such civilian platform.

b. Assistance

   The Secretary may offer assistance to private sector parties in finding appropriate opportunities for such utilization.

c. Agreements

   To the extent provided in advance by appropriation Acts, any United States Government agency may enter into agreements for such utilization if such agreements are consistent with such agency's mission and statutory authority, and if such remote sensing space system is licensed by the Secretary before commencing operation.

d. Applicability

   This section does not apply to activities carried out under subchapter III of this chapter.

e. Effect on FCC authority

   Nothing in this subchapter shall affect the authority of the Federal Communications Commission pursuant to the Communications Act of 1934 (47 U.S.C. 151 et seq.).

Appendix C: Fact Sheet on PDD-23 (Foreign Access to Remote Sensing Space Capabilities)

Source: Federation of American Scientists; http://www.fas.org/irp/offdocs/pdd23-2.htm, accessed July 9, 2006.

Note: Minor typographical errors corrected (from FAS posting).

The White House
Office of the Press Secretary

For Immediate Release March 10, 1994

Fact Sheet
Foreign Access To Remote Sensing Space Capabilities

Background

Remote sensing from space provides scientific, industrial, civil governmental, military and individual users with the capacity to gather data for a variety of useful purposes. The US Government operates very high resolution space- based reconnaissance systems for intelligence and military purposes. These systems are among the most valuable US national security assets because of their high quality data collection, timeliness, and coverage and the capability they provide to monitor events around the world on a near real-time basis. More nations have discovered the value of these satellites and are developing their own indigenous capabilities, or are seeking the purchase of data or systems.

Policy Goal

The fundamental goal of our policy is to support and to enhance US industrial competitiveness in the field of remote sensing space capabilities while at the same time protecting US national security and foreign policy interests. Success in this endeavor will contribute to maintaining our critical industrial base, advancing US technology, creating economic opportunities, strengthening the Us balance of payments, enhancing national influence, and promoting regional stability.

Scope of Policy

The policy covers foreign access to remote sensing space systems, technology, products, and data. With respect to commercial licenses, this would include operating licenses granted under the Land Remote Sensing Policy Act of 1992 and export licenses for certain items controlled on the US Munitions List (USML). While the policy will define certain restrictions for export of items on the USML, export of items on either the USML or the Commerce Control List (CCL) would continue to be licensed in accord with existing law and regulations.

Licensing and Operation of Private Remote Sensing Systems

License requests by US firms to operate private remote sensing space systems will be reviewed on a case-by-case basis in accordance with the Land Remote Sensing Policy Act of 1992 (the Act). There is a presumption that remote sensing space systems whose performance capabilities and imagery quality characteristics are available or are planned for availability in the world marketplace (e.g., Spot, Landsat, etc.) will be favorably considered, and that the following conditions will apply to any Us entity that receives an operating license under the Act.

1. The licensee will be required to maintain a record of all satellite tasking for the previous year and to allow the USG access to this record.

2. The licensee will not change the operational characteristics of the satellite system from the application as submitted without formal notification and approval of the Department of Commerce, which would coordinate with other interested agencies.

3. The license being granted does not relieve the licensee of the obligation to obtain export license(s) pursuant to applicable statutes.

4. The license is valid only for a finite period, and is neither transferable nor subject to foreign ownership, above a specified threshold, without the explicit permission of the Secretary of Commerce.

5. All encryption devices must be approved by the US Government for the purpose of denying unauthorized access to others during periods when national security, international obligations and/or foreign policies may be compromised as provided for in the Act.

6. A licensee must use a data downlink format that allows the US Government access and use of the data during periods when national security, international obligations and/or foreign policies may be compromised as provided for in the Act.

7. During periods when national security or international obligations and/or foreign policies may be compromised, as defined by the Secretary of Defense or the Secretary of State, respectively, the Secretary of Commerce may, after consultation with the appropriate agency(ies), require the licensee to limit data collection and/or distribution by the system to the extent necessitated by the given situation. Decisions to impose such limits only will be made by the Secretary of Commerce in consultation with the Secretary of Defense or the Secretary of State, as appropriate. Disagreements between Cabinet Secretaries may be appealed to the President. The Secretaries of State, Defense and Commerce shall develop their own internal mechanisms to enable them to carry out their statutory responsibilities.

8. Pursuant to the Act, the US Government requires US companies that have been issued operating licenses under the Act to notify the Us Government of its intent to enter into significant or substantial agreements with new foreign customers. Interested agencies shall be given advance notice of such agreements to allow them the opportunity to review the proposed agreement in light of the national security, international obligations and

foreign policy concerns of the Us Government. The definition of a significant or substantial agreement, as well as the time frames and other details of this process, will be defined in later Commerce regulations in consultation with appropriate agencies.

Transfer of Advanced Remote Sensing Capabilities

1. Advanced Remote Sensing System Exports: The United States will consider requests to export advanced remote sensing systems whose performance capabilities and imagery quality characteristics are available or are planned for availability in the world marketplace on a case-by-case basis.

The details of these potential sales should take into account the following:

-- the proposed foreign recipient's willingness and ability to accept commitments to the US Government concerning sharing, protection, and denial of products and data; and

-- constraints on resolution, geographic coverage, timeliness, spectral coverage, data processing and exploitation techniques, tasking capabilities, and ground architectures.

Approval of requests for exports of systems would also require certain diplomatic steps be taken, such as informing other close friends in the region of the request, and the conditions we would likely attach to any sale; and informing the recipient of our decision and the conditions we would require as part of the sale.

Any system made available to a foreign government or other foreign entity may be subject to a formal government-to- government agreement.

Transfer of Sensitive Technology

The United States will consider applications to export sensitive components, subsystems, and information concerning remote sensing space capabilities on a restricted basis. Sensitive technology in this situation consists of items of technology on the US Munitions List necessary to develop or to support advanced remote sensing space capabilities and which are uniquely available in the United States. Such sensitive technology shall be made available to foreign entities only on the basis of a government-to-government agreement. This agreement may be in the form of end-use and retransfer assurances which can be tailored to ensure the protection of Us technology.

Government-to-Government Intelligence and Defense Partnerships

Proposals for intelligence or defense partnerships with foreign countries regarding remote sensing that would raise questions about US Government competition with the private sector or would change the US Government's use of funds generated pursuant to a US-foreign government partnership arrangement shall be submitted for interagency review.

Appendix D: Commercial Space Act of 1998 (Public Law 105-303) (Section 107)

Source: National Aeronautics and Space Administration; http://geo.arc.nasa.gov/sge/landsat/sec107.html, accessed November 28, 2006.

Note: Only Section 107 of the Act is included here, since it is the only part that deals exclusively with remote sensing.

SEC. 107. SOURCES OF EARTH SCIENCE DATA.

(a) ACQUISITION- The Administrator shall, to the extent possible and while satisfying the scientific or educational requirements of the National Aeronautics and Space Administration, and where appropriate, of other Federal agencies and scientific researchers, acquire, where cost-effective, space-based and airborne Earth remote sensing data, services, distribution, and applications from a commercial provider.

(b) TREATMENT AS COMMERCIAL ITEM UNDER ACQUISITION LAWS- Acquisitions by the Administrator of the data, services, distribution, and applications referred to in subsection (a) shall be carried out in accordance with applicable acquisition laws and regulations (including chapters 137 and 140 of title 10, United States Code). For purposes of such law and regulations, such data, services, distribution, and applications shall be considered to be a commercial item. Nothing in this subsection shall be construed to preclude the United States from acquiring, through contracts with commercial providers, sufficient rights in data to meet the needs of the scientific and educational community or the needs of other government activities.

(c) STUDY- (1) The Administrator shall conduct a study to determine the extent to which the baseline scientific requirements of Earth Science can be met by commercial providers, and how the National Aeronautics and Space Administration will meet such requirements which cannot be met by commercial providers.

(2) The study conducted under this subsection shall--

(A) make recommendations to promote the availability of information from the National Aeronautics and Space Administration to commercial providers to enable commercial providers to better meet the baseline scientific requirements of Earth Science;

(B) make recommendations to promote the dissemination to commercial providers of information on advanced technology research and development performed by or for the National Aeronautics and Space Administration; and

(C) identify policy, regulatory, and legislative barriers to the implementation of the recommendations made under this subsection.

(3) The results of the study conducted under this subsection shall be transmitted to the Congress within 6 months after the date of the enactment of this Act.

(d) SAFETY STANDARDS- Nothing in this section shall be construed to prohibit the Federal Government from requiring compliance with applicable safety standards.

(e) ADMINISTRATION AND EXECUTION- This section shall be carried out as part of the Commercial Remote Sensing Program at the Stennis Space Center.

(f) REMOTE SENSING-

(1) APPLICATION CONTENTS- Section 201(b) of the Land Remote Sensing Policy Act of 1992 (15 U.S.C. 5621(b)) is amended--

(A) by inserting `(1)' after `NATIONAL SECURITY- '; and

(B) by adding at the end the following new paragraph:

`(2) The Secretary, within 6 months after the date of the enactment of the Commercial Space Act of 1998, shall publish in the Federal Register a complete and specific list of all information required to comprise a complete application for a license under this title. An application shall be considered complete when the applicant has provided all information required by the list most recently published in the Federal Register before the date the application was first submitted. Unless the Secretary has, within 30 days after receipt of an application, notified the applicant of information necessary to complete an application, the Secretary may not deny the application on the basis of the absence of any such information.'.

(2) NOTIFICATION OF AGREEMENTS- Section 202(b)(6) of the Land Remote Sensing Policy Act of 1992 (15 U.S.C. 5622(b)(6)) is amended by inserting `significant or substantial' after `Secretary of any'.

Appendix E: Fact Sheet on the U.S. Commercial Remote Sensing Space Policy (USCRSSP)

Source: Federation of American Scientists; http://www.fas.org/irp/offdocs/nspd/remsens.html, accessed June 25, 2006.

Note: The title of the Fact Sheet omitted the term "Space" from the title of the base policy.

U.S. COMMERCIAL REMOTE SENSING POLICY

April 25, 2003

FACT SHEET

The President authorized a new national policy on April 25, 2003 that establishes guidance and implementation actions for commercial remote sensing space capabilities. This policy supersedes Presidential Decision Directive 23, U.S. Policy on Foreign Access to Remote Sensing Space Capabilities, dated 9 March 1994. This fact sheet provides a summary of the new policy.

I. Scope and Definitions

This policy provides guidance for: (1) the licensing and operation of U.S. commercial remote sensing space systems; (2) United States Government use of commercial remote sensing space capabilities; (3) foreign access to U.S. commercial remote sensing space capabilities; and (4) government-to-government intelligence, defense, and foreign policy relationships involving U.S. commercial remote sensing space capabilities.

For the purposes of this document:

- "Remote sensing space capabilities" refers to all remote sensing space systems, technology, components, products, data, services, and related information. In this context, "space system" consists of the spacecraft, the mission package(s), ground stations, data links, and associated command and control facilities and may include data processing and exploitation hardware and software; and
- "Commercial remote sensing space capabilities" refers to privately owned and operated space systems licensed under the Land Remote Sensing Policy Act of 1992, their technology, components, products, data, services, and related information, as well as foreign systems whose products and services are sold commercially.

No legal rights or remedies, or legally enforceable causes of action are created or intended to be created by this policy. Officers of the United States and those agents acting on their behalf implementing this policy shall do so in a manner consistent with applicable law.

II. Policy Goal

The fundamental goal of this policy is to advance and protect U.S. national security and foreign policy interests by maintaining the nation's leadership in remote sensing space activities, and by sustaining and enhancing the U.S. remote sensing industry. Doing so will also foster economic growth, contribute to environmental stewardship, and enable scientific and technological excellence.

In support of this goal, the United States Government will:

- Rely to the maximum practical extent on U.S. commercial remote sensing space capabilities for filling imagery and geospatial needs for military, intelligence, foreign policy, homeland security, and civil users;
- Focus United States Government remote sensing space systems on meeting needs that can not be effectively, affordably, and reliably satisfied by commercial providers because of economic factors, civil mission needs, national security concerns, or foreign policy concerns;
- Develop a long-term, sustainable relationship between the United States Government and the U.S. commercial remote sensing space industry;
- Provide a timely and responsive regulatory environment for licensing the operations and exports of commercial remote sensing space systems; and
- Enable U.S. industry to compete successfully as a provider of remote sensing space capabilities for foreign governments and foreign commercial users, while ensuring appropriate measures are implemented to protect national security and foreign policy.

III. Background

Vital national security, foreign policy, economic, and civil interests depend on the United States ability to remotely sense Earth from space. Toward these ends, the United States Government develops and operates highly capable remote sensing space systems for national security purposes, to satisfy civil mission needs, and to provide important public services. United States national security systems are valuable assets because of their high quality data collection, timeliness, volume, and coverage that provide a near real-time capability for regularly monitoring events around the world. United States civil remote sensing systems enable such activities as research on local, regional, and global change, and support services and data products for weather, climate, and hazard response, and agricultural, transportation, and infrastructure planning.

A robust U.S. commercial remote sensing space industry can augment and potentially replace some United States Government capabilities and can contribute to U.S. military, intelligence, foreign policy, homeland security, and civil objectives, as well as U.S. economic competitiveness. Continued development and advancement of U.S. commercial remote sensing space capabilities also is essential to sustaining the nation's advantage in collecting information from space. Creating a robust U.S. commercial remote sensing industry requires enhancing the international competitiveness of the industry.

IV. Licensing and Operation Guidelines for Private Remote Sensing Space Systems

The Secretary of Commerce, through the National Oceanic and Atmospheric Administration (NOAA), licenses and regulates the U.S. commercial remote sensing space industry, pursuant to the Land Remote Sensing Policy Act of 1992, as amended, and other applicable legal authorities. The Secretary of Defense and the Secretary of State are responsible for determining the conditions necessary to protect national security and foreign policy concerns, respectively. NOAA, in coordination with other affected agencies and in consultation, as appropriate, with industry, will develop, publish, and periodically review the licensing regulations and associated timelines governing U.S. commercial remote sensing space systems.

To support the goals of this policy, U.S. companies are encouraged 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. However, because of the potential value of its products to an adversary, the operation of a U.S. commercial remote sensing space system requires appropriate security measures to address U.S. national security and foreign policy concerns. In such cases, the United States Government may restrict operations of the commercial systems in order to limit collection and/or dissemination of certain data and products, e.g., best resolution, most timely delivery, to the United States Government, or United States Government approved recipients.

On a case-by-case basis, the United States Government may require additional controls and safeguards for U.S. commercial remote sensing space systems potentially including them as conditions for United States Government use of those capabilities. These controls and safeguards shall include, but not be limited to: (1) the unique conditions associated with United States Government use of commercial remote sensing space systems; and (2) satellite, ground station, and communications link protection measures to allow the United States Government to rely on these systems. The United States Government also may condition the operation of U.S. commercial remote sensing space systems to ensure appropriate measures are implemented to protect U.S. national security and foreign policy interests.

V. United States Government Use of Commercial Remote Sensing Space Capabilities

To support the goals of this policy, the United States Government shall utilize U.S. commercial remote sensing space capabilities to meet imagery and geospatial needs. Foreign commercial remote sensing space capabilities, including but not limited to imagery and geospatial products and services, may be integrated in United States Government imagery and geospatial architectures, consistent with national security and foreign policy objectives.

With regard to the national security remote sensing space architecture, the Secretary of Defense and the Director of Central Intelligence, in consultation with industry as appropriate, shall:

- Determine which needs for imagery and geospatial products and services can be reliably met by commercial remote sensing space capabilities;
- Communicate current and projected needs to the commercial remote sensing space industry;
- Competitively outsource functions to enable the United States Government to rely to the maximum practical extent on commercial remote sensing space capabilities for filling imagery and geospatial needs;
- Establish the National Imagery and Mapping Agency (NIMA) as the agency of primary responsibility for acquiring and disseminating commercial remote sensing space products and services for: (1) all national security requirements; and, (2) in consultation with the Secretary of State, all foreign policy requirements.

With regard to civil remote sensing space capabilities, the Secretaries of Commerce and the Interior and the Administrator of the National Aeronautics and Space Administration (NASA), in consultation with other United States Government agencies, and with industry, as appropriate, shall:

- Determine which civil needs can be met by commercial remote sensing space capabilities; and
- Communicate current and projected needs to the commercial remote sensing space industry.

United States Government civil agencies acting individually, or when beneficial, together, shall:

- Competitively outsource functions to enable the United States Government to rely to the maximum practical extent on commercial remote sensing space capabilities for filling civil imagery and geospatial needs;
- Acquire and operate United States Government systems that collect data only when such data (1) are not offered and will not be made available by U.S. commercial remote sensing space systems; or (2) require collection, production, and/or dissemination by the United States Government due to unique scientific or technological considerations or other mission requirements; and
- Coordinate with NIMA procurement of all U.S. commercial remote sensing data and products that are restricted to United States Government or United States Government approved users pursuant to NOAA license conditions due to U.S. national security or foreign policy concerns.

Agencies shall allocate the resources required to implement these objectives within the overall policy and resource guidance of the President and available appropriations. Civil agencies may acquire commercial remote sensing space products and services directly, through cooperative arrangements with other civil agencies, or through NIMA. When procuring through another agency, civil agencies will reimburse the procuring agency, consistent with the Economy Act.

VI. Foreign Access To U.S. Commercial Remote Sensing Space Capabilities

It is in U.S. national security, foreign policy, and economic interests that U.S. industry compete successfully as providers of remote sensing space products and capabilities to foreign governments and foreign commercial users. Therefore, license applications for U.S. commercial remote sensing space exports shall be considered favorably to the extent permitted by existing law, regulations and policy when such exports support these interests.

The United States Government will consider remote sensing exports on a case-by-case basis. These exports will continue to be licensed pursuant to the United States Munitions List or the Commerce Control List, as appropriate, and in accordance with existing law and regulations. The following guidance will also apply, when considering license applications for remote sensing exports:

- The United States Government will take into account exports' potential contribution to achieving the goals of this policy, the overall relationship, particularly the existing defense and defense trade relationship with the proposed recipient nation, and broader U.S. national security, foreign policy, and economic objectives;
- As a general guideline, remote sensing exports that are currently available or are planned to be available in the global marketplace also will be considered favorably;
- Exports of sensitive or advanced information, systems, technologies, and components, however, will be approved only rarely, on a case-by-case basis. These items include systems engineering and systems integration capabilities and techniques, or enabling components or technologies, i.e., items with capabilities significantly better than those achievable by current or near-term foreign systems. The Secretary of State, in consultation with the Secretary of Defense and the Director of Central Intelligence, shall maintain a Sensitive Technology List that includes these items. This list shall be made available to U.S. industry, consistent with national security and foreign policy concerns. The Department of State shall use the list in the evaluation of requests for exports; and
- Sensitive or advanced remote sensing exports, including but not limited to a sub-set of items specifically identified on the Sensitive Technology List, will be approved only on the basis of a government-to-government agreement or other acceptable arrangement that includes, among other things, end-use and retransfer assurances that protect U.S. controlled technical data, and broader national security and foreign policy needs. Such agreements also may include protections for intellectual property and economic interests. To facilitate timely implementation, the disposition of export license applications will be expedited after completion of such agreements or arrangements.

VII. Government-to-Government Intelligence, Defense, and Foreign Relationships

The United States Government will use U.S. commercial remote sensing space capabilities to the maximum extent practicable to foster foreign partnerships and cooperation, and foreign policy objectives, consistent with the goals of this policy and with broader national security objectives. Proposals for new partnerships regarding remote sensing that would raise questions about United States Government competition with the private sector shall be submitted for interagency review. In general, the United States Government should not pursue such partnerships if they would compete with the private sector, unless there is a compelling national security or foreign policy reason for doing so.

VIII. Implementation Actions

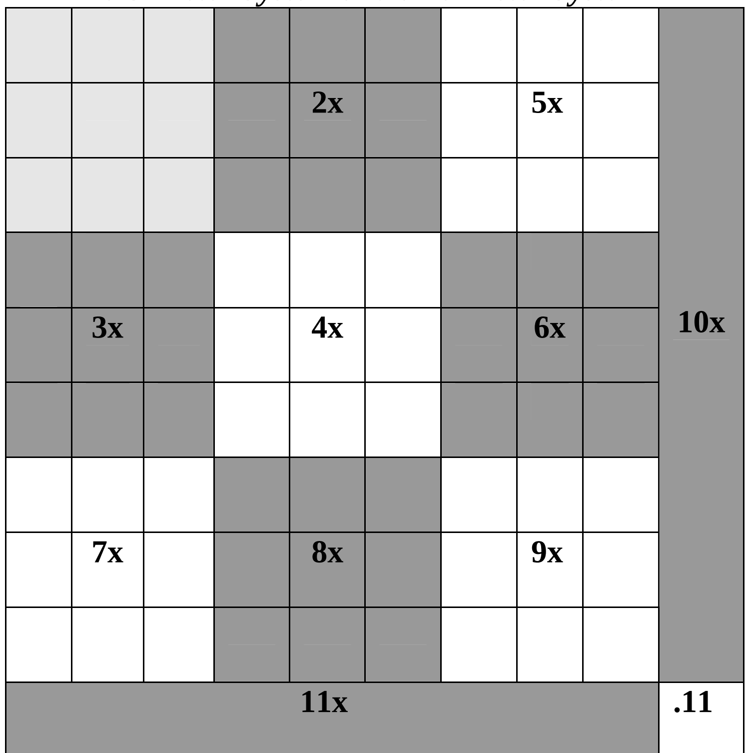
Implementation of this directive will be within the overall policy and resource guidance of the President and subject to the availability of appropriations. Agencies have been directed to complete a series of specific implementation actions within 120 days from the date of this directive.

Appendix F: Examples and Analysis of Knowledge Voids - Technical Aspects

This appendix provides detailed examples of knowledge voids related to the technical aspects of CRS. It also offers a more in-depth analysis of problems in conceptualizing or understanding spatial resolution differences and area coverage and examines the likely causes of such knowledge voids. The first example involves resolution capabilities of particular U.S. CRS satellite systems. Several other examples are also included.

Example 1 (EarthWatch Case): This is an expanded analysis of a claim made by the CEO of WorldView International during testimony given to Congress in February 1994, which asserted that WorldView would produce imagery that was three times better (i.e., 3 meters) than existing remote sensing satellites (which, if discounting Russian imagery that was actually better at 2 meters, would have been SPOT at 10 meters and Landsat at 30 meters). To analyze this claim, let us take a 3-meter resolution GSD matrix, which is nine 1-meter pixel boxes and multiply that by three in the case of the probable SPOT comparison. The calculation results in 27 one-meter pixel boxes. SPOT-2's resolution matrix actually contains 100 one-meter pixel boxes or 10 three-meter pixel boxes. Thus, discounting the Russian systems (which offered 2-meter imagery) and just considering the French system (the next best system in the world in 1994), WorldView's planned 3-meter panchromatic imaging capability would be 10x better and would obviously replace the likely reference to the Landsat 30-meter systems. Figures F.1 and F.2 below demonstrate these resolution comparisons.

Comparison of Resolution Capabilities between a 3-Meter System and a 10-Meter System



Note: The light grey box is a 3-meter-resolution pixel box, which is 3 meters x 3 meters, or 9 one-meter pixel cells. The other alternating dark grey and white boxes of nine 1-meter squares are numbered factors of difference. The .11 in the lower right=hand corner is an excess factor.

Figure F.1 – Comparison of WorldView's Projected 3-meter Panchromatic Imaging Capabilities vs. France's SPOT Satellite's 10-meter Panchromatic Imaging Capabilities

Comparison of Resolution Capabilities between a 3-Meter System and a 30-Meter System

	2x	5x	10x	17x	26x	37x	50x	65x	82x
3x	4x	6x	11x	18x	27x	38x	51x	66x	83x
7x	8x	9x	12x	19x	28x	39x	52x	67x	84x
13x	14x	15x	16x	20x	29x	40x	53x	68x	85x
21x	22x	23x	24x	25x	30x	41x	54x	69x	86x
31x	32x	33x	34x	35x	36x	42x	55x	70x	87x
43x	44x	45x	46x	47x	48x	49x	56x	71x	88x
57x	58x	59x	60x	61x	62x	63x	64x	72x	89x
73x	74x	75x	76x	77x	78x	79x	80x	81x	90x
91x	92x	93x	94x	95x	96x	97x	98x	99x	100x

Note: The light grey box is a 3-meter square pixel box indicating a 3-meter resolution capability. The entire matrix portrays a 30-meter resolution capability, which includes 99 additional 3-square meter pixel boxes for a total of a hundred 3-meter pixel boxes.

Figure F.2 – Comparison of World View's Projected 3-meter Panchromatic Imaging Capabilities vs. the U.S. Landsat-4 Satellite's 30-meter Panchromatic Imaging Capabilities

Reiterating a similar point made in Chapter 2, the reason why movement from 2 meters to 1-meter resolution results is a four-fold (i.e., 300-percent) improvement can be demonstrated by conceptualizing GSD resolution comparisons using a reverse improvement technique. Assume (for conceptualization purposes only) that going backwards (i.e., from 1 meter to 2 meters) is an improvement. If we started from a 1-meter pixel box and simply added another pixel box (which is one of the 4 quadrants of a 2-meter resolution pixel box, we would have an reverse improvement of 2x (or 100-percent change). Then, if we add the second quadrant of the 4-quadrant 2-meter pixel box (consisting of a total of four 1-meter pixel boxes, one of which is the original 1-meter box from which we started and for which we are comparing the change), we arrive at a 3x (200-percent) reverse improvement. Finally, if we add the final 1-meter box of the 2-meter-square pixel box, we get a 4x (300-percent) reverse improvement. Thus, in actuality, moving from 2-meters resolution to 1-meter resolution is a 300-percent of four-fold (4x) improvement in spatial resolution of ground objects. To be absolutely precise in conceptualizing the comparative difference between a 3-square meter resolution and 10 meters in the case of SPOT, we backtrack step by step and ultimately obtain a little over an eleven-fold difference. In the case of the Landsat comparison, 100x is exact.

Example 2 (Sensor Modes): Other technology-related knowledge voids abound in the literature on CRS. An example of such is demonstrated by analyzing a May 27, 2003 survey of the field of CRS by Joe Francica, editor Directions Magazine. Commenting on the "new government policy"[1] (i.e., the 2003 U.S. Commercial Remote Sensing Space Policy (CRSSP) of the George W. Bush administration, Francica noted that Space Imaging, Inc. (now defunct and merged with Orbimage to form GeoEye, touted as "the world's largest CRS company in the world")[2] was planning on launching a very-high-resolution (VHR) earth observation satellite with a "19-inch" pixel-resolution-capable satellite in the near future.[3] Next, Francica suspected that "the first [next-generation] sensors that will be launched would be panchromatic.[4] Obviously implied in that statement is that the next-generation (post-2003) CRS satellites that would be launched by Space Imaging or other CRS firms would only be panchromatic, not multispectral capable. Actually, such planned systems were to be both panchromatic and multispectral systems. In and of itself, the statement was partially but not completely accurate because it left out the multispectral capabilities, which were well known prior to the announcement of the CRSSP. However, such statements can potentially lead to misunderstandings or confusion about the complicated technical capabilities of CRS systems.

Ironically, over two years prior to the editorial, Space Imaging announced that it had received a license from NOAA to launch and operate a submeter CRS satellite with both panchromatic (.41 meters ground sample distance or GSD) and multispectral sensors. According to a 2001 Space imaging press release, "Space Imaging's next-generation satellite imaging system will provide half-meter resolution black-and-white (panchromatic) and two-meter resolution color (multispectral) imagery."[5] Further, the multispectral capabilities of Space Imaging's next-generation satellite were publicized in numerous other remote sensing/geospatial articles in 2001.[6] For example in November 2001, *Spatial News* issued a press release mimicking Space Imaging's earlier announcement, reporting that, "Space Imaging received license approval from the U.S. Government on December 6, 2000 to build and launch a half-meter resolution, black and white (panchromatic) and two-meter color (multispectral) imaging sensor."[7]

Even more illuminating is the fact that DigitalGlobe, another high-resolution CRS operator in the U.S. had announced in 2002 that it planned on launching a constellation of next-generation CRS satellites that would specifically offer multispectral imagery. According to a May 2002 press release, DigitalGlobe claimed, "The M5 constellation consists of four satellites, each of which will collect five-meter resolution multispectral data over a 185 kilometer-wide area."[8] The reason the foregoing technical details are mentioned here is to point out that a deep understanding of CRS satellite systems would have revealed that it is not cost effective to place single-sensor platforms into orbit. The cost to build and launch these sophistical technological systems is in the hundreds of millions of dollars and imagery from both panchromatic and multispectral sensors is an absolute must in the highly competitive marketplace of global CRS to recoup these substantial expenses.

Knowledge Gaps in Interpreting CRS Images

Two debates within the U.S. CRS arena center on policy/regulatory perceptions of the national security camp and the information transparency camp.[9] The former group is reasonably concerned that CRS imagery could be used for harmful purposes if falling into the hands of adversaries. Stakeholders in that group point out that high-resolution imagery could reveal objects and activity that the U.S. or its allies would want to protect from persons attempting to interpret widely-available CRS imagery (particularly with the advent of Google Earth imagery on the Internet). Conversely, the latter group (i.e., information transparency group but actually both groups) is concerned that imagery interpretation mistakes (by persons inexperienced in imagery interpretation) could discredit the open use CRS imagery.[10] Although there are numerous accounts of imagery interpretation mistakes by novices and of the difficulty of interpreting medium- or high-resolution earth observation imagery by non-experts (i.e., imagery interpretation knowledge or competency voids), these accounts might not be widely known by U.S. legislators or policymakers dealing with CRS issues. Not knowing or appreciating the underlying knowledge gaps (i.e., not knowing what one is perceiving in a CRS image due to lack of knowledge of or skills in imagery interpretation techniques) constitutes another knowledge gap (compound knowledge gap). The adverse implication of this phenomenon could be hypothesized as a situation where national security proponents would unduly restrict U.S. CRS imaging capabilities (resolution issues) and/or image-distribution capabilities (i.e., shutter control or the 24-hour rule) based on perceptions that CRS imagery could be readily obtained and accurately interpreted by adversaries that could threaten U.S. national security interests. Conversely and possibly even more problematic is a hypothetical situation where the news media or an NGO could inadvertently but adversely impact U.S. foreign policy interests by misinterpreting publicly available CRS imagery.

Below is a graphic representation of a condition of not knowing (i.e., upper tier knowledge void) the gaps in knowledge concerning how to proficiently interpret earth observation imagery (i.e., base tier knowledge void).

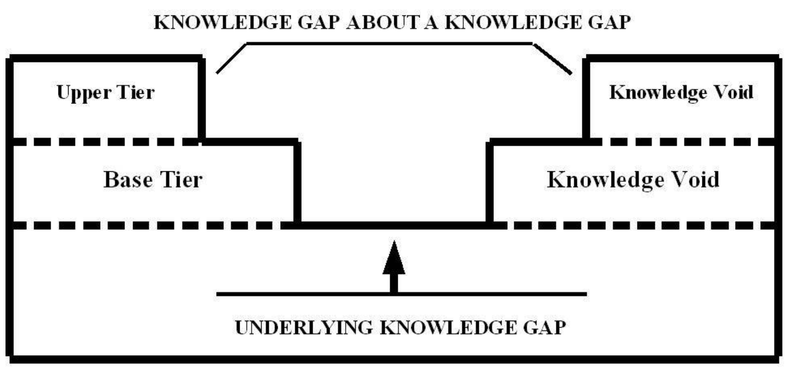


Figure F.3 - Compound Knowledge Void (not knowing or understanding **what others do not know).**

Knowledge gaps about how to interpret imagery are bad enough, but being unfamiliar with or oblivious of such gaps is even worse. Put differently, not comprehending the limitations of certain adversaries of the U.S. in their ability to interpret CRS imagery can lead to overestimation of such ability and consequently to policy or regulator regimes that restrict such imagery. Baker, Johnson, Black, and Grundhauser have all cautioned against jumping to ill-informed conclusion that potential adversaries can effectively use high-resolution CRS imagery for harmful purposes.[11] On the other hand, gaps in knowledge concerning the propensity for

NGOs, news organizations, and/or so-called “imagery activists” to misinterpret CRS imagery scenes of international flashpoints or other geographical areas under geopolitical scrutiny could create significant foreign policy issues for the U.S., as well as for other states. Thus, to craft and implement effective CRS policies and regulations for the U.S. CRS industry, it would seem prudent to know what others do not know (both the “know what” and the “know how” dimensions). The “know-what” dimension means knowing what one is seeing in the imagery and the “know how” dimension means knowing how to determine what one is seeing in that imagery. Unfortunately, this is a little studied dimension of CRS policymaking but one that needs to be the focus of additional STS research on this topic.

Knowledge Gaps Related to Imaging Area Coverage

Knowledge voids concerning CRS technology issues can really come into play when trying to estimate area coverage by CRS satellites without relying on official data from the CRS firms themselves. When one’s knowledge reservoir is shallow, one might think the estimation process is fairly simply. For example, one might know that CRS satellites orbit the earth and their orbital tracks would be 8 or 11 kilometers wide (in the case of Orbview-3 and Ikonos-2, respectively). Thus, one might assume the calculations to be fairly simple. If the earth is about 25,000 miles around its circumference (less for a polar circumference, but the satellites in question orbit at an inclinations between true polar orbits and equatorial orbits), then one might assume that the coverage of these CRS satellites would be approximately 25,000 miles (or approx 40,000 km) times 8 or 11 km. Although, it seems like simple math, multiplying 40,000 km by 8 or 11 results in 320,000 or 440,000 square km of coverage, respectively. Then, multiplying those figures by an average of 14 revolutions per day, one might (incorrectly) come up with over 4 million and 6 million square km (per day) of area coverage, respectively. Moreover, one might think that the satellite is hundreds of miles above the earth, so its orbital track must be much greater than the earth’s circumference. Fortunately, this problem is solved by the fact that we are only dealing with the imaging track along the earth’s surface, so it doesn’t make any difference how far up in space the satellite is orbiting.

Of course the forgoing assumptions are all faulty and hypothetically based on insufficient knowledge of the technical parameters of CRS systems. One actually needs to consider a multitude of other factors in attempting to calculate area coverage without official data from CRS operators. First, since Ikonos-2 is a high-resolution land-imaging satellite, it is not generally used for imaging ocean areas. The ocean-land ocean ratio of the earth’s surface is approximately 70:30, so obviously the satellite cannot image everything on every pass. Moreover, one needs to understand that at least a third of the time, CRS satellites are orbiting through the shadow of the earth or what is known as the eclipse zone. Other significant sections of the orbital passes consist of non-imaging zones to allow the satellite to position itself for solar radiation intercepts (to charge onboard batteries) and to perform other functions such as pre-imaging and post-imaging sequences and tasks. In the case of Orbview-4 (which was lost in a launch accident), the actual imaging window or time during each pass around the earth would have only been 10-minutes.[12] Further, if one’s depth of knowledge on this highly esoteric subject is sufficiently adequate, one would then realize that effectual imaging would only occur during periods of direct visibility from satellite to Earth (i.e., without significant cloud masking). Suffice it to say that its gets extremely complicated for a novice to double-check numbers this way and thus one needs to rely on official information provided by the CRS company itself. This exercise was simply done to demonstrate the difficulty in understanding the technical features of CRS satellite systems, when needing such information to make policy or regulatory decisions.

Notes

1. Joe Francica, “Dissecting the New U.S. Commercial Remote Sensing Space Policy,” *Directions Magazine* (May 27, 2003); http://www.directionsmag.com/editorials.php?article_id=367&trv=1, accessed September 2, 2006.

2. GeoEye, (website); http://www.geoeye.com, accessed May 27, 2006.

3. Francica.

4. Ibid.

5. Space Imaging, “ Space Imaging Awarded License to Provide Half-Meter Resolution Commercial Satellite Imagery: Leading Provider of Visual Earth Information Poised to be the World’s Only Source of Half-Meter Resolution Commercial Satellite Imagery” (January 19, 2001); http://www.spaceimaging.com/newsroom/2001_Half_Meter.htm, accessed May 27, 2006.

6. See GIS Development website, http://www.gisdevelopment.net/news/2001/jan/airborn.htm, accessed May 27, 2006. Also see ______, “US declassifies super res satellite imagery,” GeoPlace.com; http://www.geoplace.com/ge/2001/0301/0301enw1.asp, accessed May 27, 2006; and _____, “Space Imaging Awarded License to Provide Half-Meter Resolution Commercial Satellite Imagery,” spaceref; http://www.spaceref.ca/news/viewpr.html?pid=3630, accessed May 27, 2006.

7. _____, “Space Imaging Names Paul Tinney as Executive Vice President of Global Alliances, (November 29, 2001); http://spatialnews.geocomm.com/dailynews/2001/nov/30/news4.html, accessed May 27, 2001.

8. DigitalGlobe, “2002 Archives” (May 30, 2002); http://media.digitalglobe.com/index.php?s=press_releases&year=2002, accessed May 27, 2002. The M5-series of earth observation satellites consist of constellation of four earth-imaging platforms, each with panchromatic, multispectral, and near-infrared and short-wave-infrared spectral scanning capabilities, per DigitalGlobe. Also see _____, “GeoWorld Interview: Herb Satterlee, CEO, Digital Globe,” GeoPlace.com; http://www.geoplace.com/gr/interview/satterlee.asp, accessed May 27, 2006.

9. John C. Baker, Ray A. Williamson and Kevin M. O’Connell, “Introduction,” in John C. Baker, Kevin M. O’Connell and Ray A Williamson, *Commercial Observation satellites: At the Leading Edge of Global Transparency* (Santa Monica, CA and Bethesda, MD: RAND and the American Society for Photogrammetry and Remote Sensing, 2001), 8.

10. See John C. Baker, “New Users and Established Experts: Bridging the Knowledge Gap in Interpreting Commercial Satellite Imagery, in Baker, O’Connell and Williamson, 533-557.

11. See John C. Baker and Dan J. Johnson, “Security Implications of Commercial Satellite Imagery,” in Baker, O’Connell and Williamson, 120. Also see J. Todd Black, J. Todd Black, “Commercial Satellites: Future Threats or Allies?,” *Naval War College Review*, Vol. 52, No. 1 (Winter 1999); http://www.nwc.navy.mil/press/Review/1999/winter/art5~w99.htm, accessed September 18, 2005. In addition, see Larry K. Grundhauser, “Sentinels Rising: Commercial High-Resolution Satellite Imagery and Its Implications for US National Security,” Airpower Journal, Vol. 12 (Winter 1998); http://www.airpower.maxwell.af.mil/airchronicles/apj/apj98/win98/grundtxt.htm, accessed December 3, 2006)

12. Dewy Adams, Dominick Bruno, Piyush Shah and Brian Keller, “Precision Control, Knowledge and Orbit Determination on a Small Spacecraft Bus; The OrbView-4 Attitude Control System,” Report No. SSC98-IX-3 from the Proceedings of the 12th AIAA/USU Conference on Small Satellites (Logan, UT: Utah State University, August 1998), 3.

Appendix G: Examples and Analysis of Knowledge Voids - Organizational and System Nomenclature Aspects

Often the designations of government organizations are seemingly confusing and possibly reflect knowledge voids as they relate to CRS policy or competitiveness issues. The following are examples of knowledge voids or common errors that could have been corrected with deep knowledge of CRS-related organizations and nomenclatures. They are analyzed to determine their causes and to provide accurate knowledge on the subject.

Example 1 (Space or Science?): At the February 1994 Congressional hearing on CRS issues, Jim Frey, President of the Itek Optical Systems, one of three firms participating in a joint venture to seek a CRS license, stated that the consortium had worked "closely with industry, The Department of State, Commerce, and Defense, the Intelligence Community, the Legislature, and the Office of Space Technology Policy."[1] In the U.S., there is no Office of Space Technology Policy but there is an Office of *Science and* Technology Policy (OSTP) [italics mine] in the White House. Perhaps this is the office to which Mr. Frey was referring. A search using numerous Internet search engines produced no hits on this term prior to the date of the hearing. However, due to this knowledge glitch or misstatement, other websites or new articles picked up (or possibly duplicated) the same error. There is an Office of Technology Policy at DOC and an Office of Space Technology and Applications (OSTA) at NASA, but no "Office of Space Technology Policy" at either department/administration. There is also an Office of Space Technology Commercialization (OSTC) at DOC. More than likely it was supposed to be OSTP, since that office is heavily involved in formulating CRS policies. Without using precise and accurate office designations, it is sometimes difficult to identify the critical roles played by specific actors in the CRS policy arena.

Example 2 (USML Case): Often, non-U.S. experts on CRS confuse terminology and acronyms associated with CRS technology transfer issues. In this example, Canadian space policy expert, Corey Dvorkin wrote about the U.S. State Department's (DOS) "Munitions Control List,"[2] whereas it is actually the U.S. Munitions List (USML). The error was likely based on confusion or conflation of the U.S. Department of Commerce's (DOC's) control regime called the Commerce Control List (CCL), which is entirely separate from DOS's USML. Although partial unfamiliarity with the subject matter of U.S. CRS policy and regulations is understandable given its vast and confusing labyrinth of facts and information, errors such as these tend to pollute the literature on U.S. CRS issues and create misinformation which can be duplicated in other studies and reports on the subject.

Exact knowledge of the USML also seems to be a problem for other officials dealing with CRS matters, as well. For example, during the third Congressional hearing on the Commercial Space Act (1997 version) on June 4, 1997, Cheryl Roby, Principal Deputy to the Assistant Secretary for C^3I, responded to a question from Congressman Bud Cramer, ranking member of the House Committee on Space and Aeronautics concerning sales of CRS systems to foreign clients. Roby responded by stating, "Under the Military Munitions List, that is something, I mean, the Military's List, that is something the State Department does, so we [DOD] don't have an answer either."[3] Actually, exports of satellites and associated technology were covered by DOC's Commerce Control List (CCL) until 1999, so DOS would not have been involved as of the date of the aforementioned hearing. Furthermore, control over exports of satellites and associated technology was not transferred from DOC to DOS's USML until March 14, 1999 (almost two years after the June 1997 House hearings).[4] Still, DOS had control of CRS satellite exports up until 1991, so its possible that the incorrect knowledge involved here was dated or behind the times. Currently, the USML is covered in Part 121 of the International Traffic in Arms Regulators (ITAR) stemming from the Arms Export Control Act.

Remote sensing satellite systems are listed as Category XV items in Part 201 (USML) of the ITAR. Control over CRS satellite exports was transferred back to DOS as mandated by the National Defense Authorization Act for FY 1999.[5] Although military items are termed "significant military equipment (SMEs)" in a different section, nowhere in the regulations is the term "military munitions list" (MML) to be found.[6] Actually, MML is an acronym used within DOD[7] and does not appear to be related to the USML that is supervised by DOS. Even legal jargon related to remote sensing satellite export control regimes can be confusing to those with some background in the subject matter, particularly when CRS satellites have been used as a political football. For instance, CRS satellites and technology were once on the USML, but a 1990 decision by President George H. W. Bush resulted in the transfer of CRS satellites back to DOC's CCL on June 1, 1991 (where they remained until they were transferred back to DOS's USML in 1999).[8]

Example 3 (EROS Case): Often, CRS watchers are confused by the full designations of U.S. satellite systems, reflecting slight knowledge gaps on this particular subject matter. Similar to Congressman Rohrabacher's gaff (described in Chapter 3) by calling the Earth Resources Technology Satellite (ETRS; initial name of Landsat) the "Earth Resources Terrestrial Survey Satellite," Canadian scholars Michel Bourbonniere and Louis Haeck (associate professor at the Royal Military College of Canada/RMCC and adjunct professor at the University of Montréal and RMCC, respectively), writing on U.S.-Canadian cooperation in remote sensing programs referred to an early NASA project predating ERTS-1/Landsat-1 as the "Earth Resources Orbiting Satellite" [EROS] project."[9] NASA's EROS program was actually the Earth Resources *Observation* Satellite program [italics mine]. Much more knowledgeable scholars, such as Pamela Mack, who wrote the definitive history of the early Landsat program (partially funded by Virginia Tech), correctly described the program ("Earth Resources Observation Satellite/System"), which was the brainchild of DOI.[10]

So are these deficient knowledge-based statements consequential? Perhaps! Such cognitive phenomenon is also described at length in Chapter 4. Here, it is instructive to determine the etiology of these mistakes or to determine their causes and why incorrect knowledge was formed in the first place. Initially, one can actually conduct a reverse logical-reasoning exercise. To do so, all we need to do is simply reorder the correct term "Earth Resources Observation Satellite" and work backwards (i.e., Satellite Observation Resources Earth) and reflexively ask a series of questions. For example, what does the satellite do? It observes. What does it observe? It observes resources. What resources does it observe? It observes resources of the Earth. This all entails a semantically logical sequence. Now, we consider the incorrect designation "Earth Resources Orbiting Satellite." First of all, all man-made spacebased satellites orbit the earth (or other celestial bodies) so the term orbiting is somewhat redundant or unnecessary. Secondly, let's reorder the phrase and work backwards. What does the satellite do? It orbits. So far, very logical. Next, what is the relationship between the terms "orbiting" and "resources?" Clearly the satellite does not orbit the resources (unless one considers the entire Earth as resources). Instead, the more logical relationship is that it (i.e., the satellite) "observes" the "resources" from space.

Research for this dissertation also resulted in identifying the incorrect designation on an official Canadian website of the Canadian Center for Remote Sensing (CCRS), as updated to the late date of January 26, 2006.[11] Ironically, drilling further down, it was detected that the same incorrect term was ascribed to the Israeli satellite system (i.e., EROS or Earth Resources Orbiting Satellite), by a well-known scholar and writer on Middle-Eastern CRS systems, Gerald Steinberg, in one of his papers posted on an Israeli university website."[12] Of note, Steinberg correctly wrote back in 2001 that the Israeli system (EROS) was the "Earth Remote Observation System"[13] and it was still called that as late as April 2, 2006.[14] The incorrect terminology for the Israeli system was subsequently repeated in October of the same year (2005) in an obscure web journal, TBRNews. The article stated: "IAI is developing the EROS (Earth Resources Orbiting Satellite) with 2-3 meter resolution capability,"[15] likely picking up the inaccuracy from other new sources and possibly traced back to Steinberg's paper.

Drilling even further back, another source of the erroneous designation was identified, which possibly demonstrated foggy knowledge recall. When interviewed in 1996 by Stanley Scott, former Research Associate with the University of California, Berkeley, Robert E. Wallace, Scientist Emeritus, USGS, Menlo Park, California, recalled: "I wish I knew some details, but somehow Bill Pecora early-on managed to get the authority and money to launch a satellite, now called "LANDSAT," earlier known by another names, I think one was "EROS" for "Earth Resources Orbiting Satellite," which proved invaluable for studying natural resources.[16] What is amazing is how these knowledge vacuums are globally propagated, as evidenced by numerous Internet hits – from the U.S. to websites in counties such as the U.K. and Japan, etc. (all mimicking the incorrect designation). For example the USGS's EDC (EROS Data Center) has often been called the Earth Resources *Orbiting* [italics mine] Satellite Data Center, even on a NASA (Kennedy Space Center) website.[17] Actually, EDC was the former acronym for the Earth Resources *Observation* [italics mine] System Data Center (now called the USGS National Center for Earth Resources Observation and Science (EROS) Data Center, in Sioux Falls, South Dakota.[18] The saga of the bogus term seems to trace all the way back to a NASA data (web) archive dated March 1, 1994.[19]

Example 4 (U.S. CRS Firms and Systems): Often, space policy officials confuse U.S. companies that operate CRS satellites. This is a knowledge void that should be easily corrected because there are not that many U.S. CRS firms to keep straight (previously three and now only two). Nevertheless, writing about the U.S. controls on access to U.S. CRS imagery as an example of recommendations for establishing similar laws in Canada, Dana Clarke, a military space official in the Canadian Department of National Defense, reflected a knowledge gap when discussing U.S. CRS systems in the late 1990s. After introducing the Ikonos-2 CRS satellite operated by Space Imaging, Clark noted, "Orbital, the operator of the Ikonos, have [sic] applied to the Department of Commerce for a license to build and operate a .5 meter panchromatic satellite."[20] Actually, it was not Orbital (i.e., Orbital Sciences) that was the operator of Ikonos; instead, it was Space Imaging, a totally separate company. Moreover, Clark continued discussing Space Imaging by stating, "Space Imaging is planning to offer 1 meter panchromatic and 4 meter multi-spectral imaging capability on its Orbview 3 and 4 satellites, with the latter adding an 8 meters hyperspectral sensor."[21] Again, one encounters mass confusion with understanding or knowing which companies operate which satellites. At the time of Clarke's writing (prior to November 17, 2000, the first date of a conference where his paper was submitted), Space Imaging only operated one satellite and that was Ikonos. Since then, Space Imaging has merged with Orbimage under the name GeoEye. Yet, even as of 2004, Orbview-3 and -4 satellites (the latter failed to reach orbit) were built and operated (planned to be operated in the case of Orbview-4) by Orbimage (a former subsidiary of Orbital Sciences), not by Space Imaging.

Example 5 (First Remote Sensing Satellite): Even recall or knowledge claims are occasionally flawed or muddled when it comes to tracing the history of CRS technology and policy dimensions. The following is an example of a knowledge glitch concerning the early history of space-based remote sensing. In a 2004 paper presented at Michigan State University, Michael Belligan (citing comments by Corey Dvorkin, mentioned in Example 5) wrote, "The first satellite to be used to obtain remotely sensed imagery was the KH-1 military reconnaissance satellite in July 1959."[22] Two things are wrong with that statement and it reflects a knowledge gap concerning the early period of remote sensing history. First, it was actually NASA's Explorer-6 that was the first satellite used to obtain remotely sensed images of the earth in August 1959. Secondly, the KH-1 series of military reconnaissance satellites did not produce their first photos of the earth until August 1960, a full year later.[23] Of course this is not totally the oversight of Belligan. Instead, the knowledge gap resides more with Dvorkin, a Canadian defense policy official.

Example 6 (WorldView-Space Imaging Connection?): A separate example of several instances of knowledge void-based errors were in Dvorkin's chapter of a 2004 book on CRS policy issues edited by James Keeley and Rob Huebert. In that chapter, which discussed the strategic use of CRS imagery, Dvorkin wrote, "….in July 1992, only 2 months before P.L. 102-555 [the Land Remote Sensing Policy Act] was signed into law by President George H.W. Bush, WorldView Inc. in partnership with Space Imaging applied for a license to develop its 'Early Bird' satellite with a 3 m resolution."[24] Yet, nothing could be further from the truth. To set the record straight and to provide accurate information, Space Imaging was never in partnership with WorldView Inc. (aka WorldView Imaging Corp. of Livermore, California), which was later renamed Earth Watch when it partnered with Ball Aerospace and Technologies Corp. and then finally renamed DigitalGlobe (a competitor of the former Space Imaging Inc).

To develop the Early Bird satellite, EarthWatch partnered with Ball Aerospace, not Space Imaging. Moreover, Space Imaging (then, Space Imaging International) of Thorton, Colorado was not even formed until October 1994 when it spun off from Lockheed Martin Space Systems. Space Imaging pursued development of the Ikonos satellite, not the EarlyBird. Still, there was a Space Imaging under Lockheed Martin at that time. Dvorkin's source for this information was Florini and Dehqanzada's paper submitted to a July 1999 Conference entitled "No More Secret? Policy Implications of Commercial Remote Sensing Satellites." According to Florini and Dehqanzada, "In July 1992, shortly before the Land Remote Sensing Policy Act was signed into law, WorldView Inc. applied for a license to operate a commercial satellite capable of achieving three-meter panchromatic images of earth."[25] Interestingly, Florini and Dehqanzada provided a table in their paper that showed Lockheed Space Imaging did not apply for their license until 10 July 1993.[26] Perhaps confusion associated with the term "partnership" came from the fact that Lockheed Martin (which had a division called Lockheed Space Imaging) also applied for a CRS licensing around the 1992 timeframe. One might surmise that such confusion came from conflating the second term in "Space Imaging" with the second term in "WorldView Imaging?" Such confusion over separate and unrelated CRS organizations is a distinct possibility. In the world of CRS, there seems to be too many names, systems, laws, policies, dates, and technical details to keep them all straight.

***Example 7 (Autometric* Case)**: An extreme knowledge gap was manifested in IEEE's *Spectrum* report concerning the function of a U.S. geospatial company called Autometric of Springfield, Virginia. According to James Oberg, the author of the report, Autometric was incorporated in the Cayman Islands and planned on initiating "operation of an Israeli-built, Russian-launched 1-meter vehicle, also before the end of 1999."[27] Actually, Autometric is a company that is fully incorporated in the U.S. This erroneous association was likely based on confusion with another firm called West Indian Space of the Cayman Islands. To further compound previous errors, the report confused Autometric with the Israeli EROS satellite systems to be launched in the post-2000 era. According to Oberg, "Autometric plans to launch up to eight [EROS satellites] in the next three years."[28] To the contrary, Autometric is not a company that builds, launches, or operates imaging satellites. Instead of Autometric (a U.S. company), it was West Indian Space (later named ImageSat International) that was involved in this project. The confusion with an American company probably stems from not knowing that it was Core Software Technologies of Pasadena, California that was an investor in the EROS project for Israel, not Autometric, which is in Virginia and is an imagery value-added firm only. More tellingly, Autometric pointed out these errors and a retraction was supposed to have been issued in a subsequent issue of *Spectrum*.[29]

Example 8 (EROS or Ofeq?): CRS-related knowledge gaps also occur in the research and reporting by seemingly knowledgeable officials in remote sensing associations and societies. For example, Lawrence Fritz, past president of the International Society for Photogrammetry and Remote Sensing [ISPRS], wrote that the Israeli CRS satellite "EROS-A" was launched on 22 January 1998 but failed to reach orbit.[30] He even included a table that indicated that EROS-A failed in January 1998.[31] Actually, it was not EROS that was launched then, but the Israeli military satellite Ofeq-4. Even experts in the CRS field are occasionally confused with the multitude of international CRS systems and their nomenclatures and this is just one of such examples. Yet, it is particularly important to at least be able to distinguish between military and civil/commercial satellite systems. The satellite that failed to reach orbit due to a booster malfunction was not the commercial EROS-A (later dubbed EROS-A1) satellite, but was the Ofeq-4 (Horizon-4), an Israeli military reconnaissance satellite.[32] The first EROS satellite (EROS-A) was successfully launched and orbited on December 5, 2000.[33]

Notes

1. Jim Frey, statement in U.S. House of Representatives, Committee on Science, Space, and Technology and Permanent Select Committee on Intelligence, *Commercial Remote Sensing in the Post-Cold War Era* (Washington, DC: U.S. Government Printing Office), 119.

2. Corey Michael Dvorkin, "Two Steps Back: The Uncertain Promise for the Strategic Use of Commercial Satellite Imagery," in James F. Kelley and Robert N. Huebert, eds. *Commercial Satellite Imagery and UN Peacekeeping* (Burlington, VT: Ashgate Publishing Company, 2004), 159.

3. Cheryl Roby, statement in U.S. House of Representatives, Committee on Science, Subcommittee on Space and Aeronautics, Hearings on the Commercial Space Act of 1997, Part III: Commercial Remote Sensing, June 4, 1997, 104; http://commdocs.house.gov/committees/science/hsy141160.000/hsy141160_0.htm, accessed October 31, 2005.

4. David Beck, et. al., "Industry Studies 2000: Space" (ICAF Industry Studies, 2000 Report on Space); http://www.ndu.edu/icaf/industry/2000/space/space.htm#_edn48, accessed June 18, 2006.

5. Jack Shane, "Licensing Jurisdiction for Space-Based Equipment/Export Issues for Research Universities" (Washington, DC: Wiley Rein and Fielding LLP, May 12, 2005) 6; http://www.wrf.com/docs/events/1188.pdf, accessed June 18, 2006.

6. Code of Federal Regulations, Title 22, Part 102 (The United States Munitions List); http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=03a931bd08388c73093352157a54df60&tpl=/ecfrbrowse/Title22/22cfr121_main_02.tpl, accessed June 18, 2006.

7. Richard D. Long, *Report No. 08016-1-SF; Follow-Up Review of Forest Service Security Over Aircraft and Aircraft Facilities* (Washington, DC: U.S. Department of Agriculture, September 30, 2003), 31.

8. _____, "403.Transfer of Certain Remote Sensing Satellites from the U.S. Munitions List to the CCL" (Washington, DC: U.S. Department of Commerce); http://ciir.cs.umass.edu/cgi-bin/ua/web_fetch_doc?dataset=ua&db=agendaApril1996&doc_id=x0694-AB09&query=and, accessed June 18, 2006.

9. Michel Bourbonniere and Louis Haeck, "Canada's Remote Sensing Program and Policies," in John C. Baker, Kevin M. O'Connell, and Ray A. Williamson, *Commercial Observation Satellites: At The Leading Edge of Global Transparency* (Santa Monica, CA and Bethesda, MD: RAND and American Society for Photogrammetry and Remote Sensing, 2001), 276.

10. Pamela E. Mack, *Viewing the Earth: The Social Construction of the Landsat Satellite System* (Cambridge, MA: The MIT Press, 1990), 59, 85, 262.

11. _____, “Remote Sensing Then and Now, Leap Into Space,” CCRS; http://ccrs.nrcan.gc.ca/org/history/history2_e.php, accessed April 2, 2006.

12. Gerald M. Steinberg, “Satelite [sic] Capabilities Of Emerging Space-Competant [sic] States” (Ramat Gan, Israel: Bar-Ilan University, April 13, 2005); http://faculty.biu.ac.il/~steing/military/sat.htm, accessed April 2, 2006.

13. Steinberg, “Commercial Observation Satellites in the Middle East and the Persian Gulf,” in Baker, O’Connell and Williamson, 225.

14. _____,”EROS-A (Earth Remote Observation System-A),” eoPortal (European Space Agency/ESRIN in Frascati, Italy), http://directory.eoportal.org/pres_EROSEarthRemoteObservationSatellite.html, accessed April 2, 2006. Also see Barbara Opall-Rome, “Israel Building New Radar Satellite,” *C^4ISR* (March 4, 2005); http://www.isrjournal.com/story.php?F=700606, accessed April 2, 2006.

15. _____, “With Friends Like This, Who Needs Enemies,?” *TBRNews*, October 17, 2005**;** http://www.tbrnews.org/Archives/a1912.htm, accessed April 2, 2006.

16. Robert E. Wallace, “Earthquakes, Minerals and Me: With the USGS, 1942-1995,” (U.S. Geological Survey open-File Report 96-260), 1996; http://quake.wr.usgs.gov/research/history/wallace-XI.html, accessed 2 April 2006.

17. NASA, “SPACE/DATA - Online and Other sources of Images and Data” (March 1, 1994); http://www.ksc.nasa.gov/facts/faq03.html, accessed April 2, 2006.

18. O’Connell and Hilgenberg, in Baker, O’Connell, and Williamson, 143. Also see Mack, 262. In addition, see USGS website; http://eros.usgs.gov, accessed April 2, 2006.

19. NASA, “SPACE/DATA - Online and Other sources of Images and Data.”

20. Dana G. Clarke, “Access Control of Remote Sensing Satellites,” in Keeley and Huebert, 172.

21. Ibid.

22. Michael Belligan, “Mixed Signals: A History of the Landsat Program and U.S. Commercial Remote Sensing Industry” (unpublished paper) (Fall 2004); http://www.msu.edu/~belliga1/GEO801_LANDSAT.htm, accessed May 27, 2006.

23. Federation of American Scientists, “KH-1 CORONA;” http://www.fas.org/spp/military/program/imint/kh-1.htm, accessed May 27 2006.

24. Dvorkin, 151.

25. Ann M. Florini and Yahya A. Dehqanzada, “No More Secrets? Policy Implications of Commercial Remote Sensing Satellites,” (working paper No. 1 prepared for a conference by the

same title) (July 1999); http://www.ceip.org/programs/governance/remotesensingconf/NoMoreSecrets1.htm, accessed June 13, 2004.

26. Ibid.

27. James Oberg, "Spying for Dummies: The National Security Implications of Commercial Space Imaging," *Spectrum*, (November 1999); http://jamesoberg.com/articles/spy/, accessed May 28, 2006.

28. Ibid.

29. Ibid.

30. Lawrence W. Fritz, "High Resolution Commercial Remote Sensing Satellites and Spatial Information Systems," *ISPRS Highlights*, Vol. 4, No. 2 (June 1999); http://www.isprs.org/publications/highlights/highlights0402/fritz.html, accessed May 21, 2006.

31. Ibid.

32. Steinberg. "Commercial Observation Satellites in the Middle East and the Persian Gulf," 230. Also see Center for Nonproliferation Studies, "Israel: Military Programs;" http://cns.miis.edu/research/space/israel/mil.htm, accessed 27 May 2006.

33. Steinberg, "Commercial Observation Satellites in the Middle East and the Persian Gulf," 232. Also see ______, "IAI EROS Commercial Satellite Launched Successfully," *Israel High-Tech and Investment Report* (January 2001); http://www.ishitech.co.il/jan01ar2.htm, accessed May 27, 2006. Also see ImageSat International, "EROS Satellites," ImageSat (2005); http://www.imagesatintl.com/default.asp?catid={C3836EEE-A141-4314-9E7D-B137378069F5}, accessed May 27, 2006. In addition, see ImageSat International, "EROS A," ImageSat (2005); http://www.imagesatintl.com/?catid={D76C171A-56A7-48F4-B49C-C4FB14212FD7}, both accessed May 27, 2006.

Appendix H: Example and Analysis of Knowledge Voids – Legal and Policy Aspects

During research for this dissertation, it was noticed that many CRS observers and stakeholders are confused about various legislative actions setting forth the goals to commercialize remote sensing. In fact, legal and policy aspects seems to be the largest stumbling block for people attempting to understand and explain the implications of such laws and policies for U.S. CRS activities. Since the examples are so numerous, they will not be numbered. Analysis of these types of knowledge voids supplement the discussions of structural knowledge voids in Chapter 4 under the legal and policy knowledge voids subsection.

In a 1999 article in Space Imaging's *Imaging Notes*, two authors from the Stennis Space Center referred to the "1984 Land Remote Sensing *Policy* [italics mine] Act" that sought to privatize civil remote sensing operations.[1] The 1984 act was actually the Land Remote Sensing *Commercialization* [italics mine] Act. Another example was a 1997 statement provided at a hearing on the commercialization of space before the U.S. House of Representatives' Committee on Science (Subcommittee on Space and Aeronautics). According to one of the witnesses, Molly Macauley, "Another approach, in the 1992 Land Remote Sensing *Commercialization* [italics mine] Act, would provide for the issuance of data vouchers to scientists….."[2] This time the error was reversed; the 1992 Act was actually the Land Remote Sensing *Policy* [italics mine] Act.

Policy directives issued by various administrations are even confusing to numerous researchers studying the politics of CRS. For example, writing in 1995 on the national security implications of high-resolution commercial imagery, Vipin Gupta, then postdoctoral fellow at the Center for Security and Technology Studies at Lawrence Livermore National Laboratory, repeatedly called President Clinton's PDD-23, "PD 23" (or "Presidential Decision"-23).[3] Gupta is not alone is these slight knowledge gaps. Three years later in 1998, Gerald Steinberg incorrectly cited the directive at least 17 times throughout a journal article on the dual-use aspects of CRS.[4] The misnomer also occurred during the same year in a discussion paper (reflecting results of research on remote sensing systems funded by the Environmental Protection Agency), which was co-authored by a senior fellow at a Washington, DC think tank and a policy sciences and economic professor at the University of Maryland, Baltimore College.[5]

Another example of unfamiliarity with CRS legal issues was salient during a discussion that took place at the public session of the fall 2005 ACCRES meeting. Greg Snyder, USGS representative from the EROS Data Center (EDC), briefed on EDC's plans to store earth observation data generated by U.S. CRS satellite operators (i.e., data archiving). Just a few months prior to the ACCRES meeting, USGS visited the then "Big Three" CRS firms (DigitalGlobe, Space Imaging, and Orbimage) to discuss data archive transfer issues.[6] At the ACCRES meeting, Gabrynowicz queried Snyder about whether USGS understood the ramifications of such a plan, since it could potentially create a "bailment" situation. Snyder then asked, "what is a bailment?"[7] Another unidentified participant in the ACCRES session commented that "that was just lawyer talk," whereupon Gabrynowicz cautioned the group that "bailment" is something that USGS should be very concerned about and recommended that their legal counsel study the potential legal issue.[8]

Another example of CRS-related knowledge voids occurred during a January 2000 interview of John Copple (then-president of Space Imaging) in ASPRS's journal *Photogrammetic* [sic] *Engineering and Remote Sensing (PE&RS)*. According to Copple, "The current U.S. laws are aimed at encouraging private investment in remote sensing technology. However, the policy (under the Landsat Remote Sensing Act of 1992) that created this opportunity also is in conflict with the objectives because of legacy issues regarding government funding of remote sensing satellites."[9] Again, confusion of this sort comes from the fact that the bulk of the Act addresses the Landsat system, even though the act's actual title is the Land Remote Sensing Policy Act of 1992 (Public Law 102-555). First of all, it starts with "land Remote Sensing….," not "Landsat Remote Sensing….." Secondly, the term "Policy" is often mistakenly omitted when referencing the Land Remote Sensing Policy Act, and the law is also often misstated as the "Landsat" Act, whereas it is what I call the "Policy Act," similar to what I call the "Commercialization Act" for the Land Remote Sensing Commercialization Act of 1984. In other words, the Act was not just about Landsat. In additional to major portions on the Landsat program, the 1992 legislation also included portions on CRS systems and even weather satellites.

Confusion over the precise nomenclature for CRS-related laws is fairly abundant. For example, citing a RAND study by Johnson, Nelson, and Lempert entitled *US Space-Based Remote Sensing Challenges and Prospects*, a well-known expert in CRS and scholar at the Bar-Ilan University (Israel) wrote: "Escalating Landsat costs led to its commercialization in 1983, and in 1984 the Land Remote Sensing *Policy* Act [italics mine] turned over Landsat operations to the EOSAT."[10] Actually, the 1984 Act was the Land Remote Sensing *Commercialization* Act (italics mine).

The foregoing example of a structural (legal-policy) knowledge void is not an isolated one. For instance, at a moot court competition held in the International Court of Justice in the Hague in 2001, a document on the "Case Concerning Access to ESI-1 Data: Saliscalor v. Cornucopia" had a "Legal Materials" section that included the "Land Remote Sensing Commercialization [should be 'Policy'] Act of 1992 and the footnote number 23 listed the act by the same erroneous title.[11] The International Institute of Space Law (IISL) based in Paris, France organizes the annual moot court event. Even an expert on public policy for remote sensing provided similarly incorrect information at a Congressional hearing. During a May 21, 1997 hearing held by the U.S. House of Representatives' Committee on Science, Subcommittee on Space and Aeronautics, Molly Macauley of a Washington D.C. think tank, Resources for the Future, stated that "Another approach, in the 1992 Land Remote Sensing *Commercialization* Act (italics mine), would provide for the issuance of data vouchers to scientists ……"[12] The 1992 Act was actually the 1992 Land Remote Sensing *Policy* Act (italics mine), whereas the "Commercialization Act" was passed in 1984.

Yet another example of confusion over the titles of remote sensing policy legislation was detected in *Imaging Notes*, a journal of the former CRS firm, Space Imaging. In an article in the July/August 1999 edition, the lead sentence in the section on policy milestones reported that: "The 1984 Land Remote Sensing *Policy* Act [italics mine] sought to privatize operations of the civil government remote sensing program."[13] Again, the 1984 Act was the Land Remote

Sensing *Commercialization* Act" [italics mine]. Admittedly, the similar designation of the two Congressional acts can be confusing.

Not only are the titles of major U.S. CRS laws very confusing, the titles of presidential directives can also be misstated due to apparent knowledge voids on this aspect of CRS policymaking. Put differently, the terminology or designations of presidential directives are often confused in the literature on CRS policy. President Carter's PD-54 is a prime example; in July 1999, Florini and Dehqanzada referred to it "Presidential Decision Directive (PDD-54)."[14] Actually, Presidential Decision Directives were only issued by the Clinton administration. In another instance, a NASA editor wrote that NSDD-42 replaced the three Carter administration directives ("NSDD-37, NSDD-42, and NSDD-54"),[15] whereas none of them were National Security Decision Directives (NSDD's) and, instead, were Presidential Directives (PDs). Reagan's' NSDD-37 was actually on Cuba and Central America policies. Even more ludicrous is the fact that (should the NASA editor's statement not be corrected) NSDD-42 would actually be replacing itself. Instead, NSDD-54 is a directive on U.S. policies toward Europe. Neither NSDD-37 nor NSDD-42 has anything to do with remote sensing or space policy. All USG administrations have used different designations for their directives. In this case, all of the directives issued by the Carter administration were designated as "Presidential Directives (PD's).[16]

No U.S. President since Jimmy Carter has issued Presidential Decisions or PDs. President Carter issued sixty-three Presidential Directives (PDs),[17] President Regan issued three-hundred and twenty-five National Security Decision Directives (NSDDs),[18] President George H.W. Bush issued seventy-nine National Security Directives (NSDs) and seven National Space Council Directives (NSCDs),[19] President Clinton issued eighty-three Presidential Decision Directives (either as PDDs from the National Security Council known as PDD/NSCs or from the National Science and Technology Council known as PDD/NSTCs),[20] and President George W. Bush issued forty-three National Security Presidential Directives (NSPDs) and fourteen Homeland Security Presidential Directives (HSPDs).[21] The bottom line is that, since President Carter, each U.S. President has used different titles for their policy directives relating to national security or technology issues. It is important to know the exact titles of these presidential decisions so that, if they are rendered as acronyms, one can conduct research on CRS issues by correctly identifying the documents.

In another example of legal/policy knowledge voids, Corey Dvorkin wrote about "PDD-54" issued in July 1997 by the Carter administration.[22] There is no such directive as PDD-54; instead it was Presidential Directive (PD-54). The error actually came from Florini and Dehqanzada's paper (previously cited) and was not double-checked. The point here is that inaccurate information (which could be immediately corrected if there were deeper knowledge reservoirs) is often transferred from one CRS study to the next, ad infinitum. Yet, if we overlook this example, there are others that beg analysis to determine their causes. Most striking was Dvorkin's discussion of PDD-23 (Clinton administration policy of CRS). Obviously citing the fact sheet to PDD-23 since it is the only publicly available information on that policy, Dvorkin, noted that "PDD-23 lowered the threshold for commercial electro-optical imagery to 1-meter resolution, and synthetic aperture radar (SAR) to a resolution of five meters, and opened the door, however cautiously, for American dominance of the market."[23] Nothing in the fact sheet to PDD-3 mentions anything about 1-meter EO constraints (thresholds) or 5-meter radar constraints for U.S. CRS licensing applications or CRS satellite operations. This misinformation has been called a "myth" by Florini and Dehqanzada.[24] After substantial research for this dissertation, this so-called "myth" was traced back to a 1999 article by J. Todd Black on commercial satellites, wherein the so-called language about 1-meter resolution being of national security concern was ascribed to PDD-23.[25] The source for this supposed language was a March 10, 1994 press release (fact sheet) from the White House on PDD-3. Ironically, in the same citation (i.e., endnote 8), Black also referenced a 1995 article in MIT's journal, *International Security*, by Vipin Gupta, which in part, covered CRS resolution issues.[26] A careful reading of Gupta's original report, dated September 28, 1994[27] and revised on December 12, 1994, which was accepted for publication by *International Security*,[28] might have filled in the knowledge gap that likely led to a chain of erroneous statements termed a "myth" by Florini and Dehquanzada. For example, writing about PDD-23 (and citing as its source the March 10, 1994 fact sheet), Gupta noted, "However, the line distinguishing between acceptable and unacceptable private remote sensing systems has yet to be drawn. The policy does not specify what technical and operational capabilities would be considered inherently threatening to US national interests."[29] Although that second sentence was omitted from MIT's *International Security*, the lead sentence was essentially the same (i.e., "The line has yet to be drawn distinguishing acceptable from unacceptable private remote sensing systems…)"[30]

In yet another example of knowledge gaps concerning CRS-related legal documents, a 2002 Congressional Research Service (CRS) report contained several errors and inaccuracies, which manifest significant knowledge voids on the subject. Page 15 of that report contains the following statement: "The Act [Land Remote Sensing Policy Act; 15 USC 82] also prohibits use of remote sensing to gather, transmit, or deliver defense related information for the benefit of any foreign government or to publish photographs of defense facilities."[31] This statement is completely inaccurate, but one needs to read the previous verbiage to understand the context. Actually, the 1992 Policy Act says nothing about such a prohibition. Instead, the inaccurate statement stems from confusion about another law discussed by Bob Preston (which was the source cited) in his chapter of a book entitled "Commercial Observation Satellites."[32] Actually, Preston was not writing about the Land Remote Sensing Policy Act; rather, he was writing about 18 USC 793, 794, and 795.[33]

In another example from the same CRS report, an additional knowledge void indicator was detected. According to the report, "….PDD-23 also promotes the remote sensing industry and provides for low cost access to the images for the United States."[34] This statement is only partially accurate. Although the directive promotes the remote sensing industry, the fact sheet to PDD-23 (i.e., the only publicly available document on PDD-23) says nothing about providing "low cost access to images for the U.S." Furthermore, PDD-23 (fact sheet) primarily addresses commercial remote sensing space systems and imagery from such systems would not be considered "low-cost" even for the USG. It is possible that the statement was indicative of confusion over the concept of COFR (or cost of fulfilling a user requests), which is associated with the Landsat system as mentioned in the 1992 Policy Act. However, PDD-23 does not discuss COFR.

Finally, the same CRS report contained a knowledge gap concerning the contents of the Commercial Space Act of 1988. According to the report, "An attempt was made to clarify the regulations during the 105th Congress, but no amendments to the 1992 Act were included in the Commercial Space Act of 1998."[35] Again, this statement is factually incorrect. Actually the CSA does contain amendments to the 1992 Policy Act. Note the terms "Land Remote Sensing Policy Act" and "amended" from the language of the Commercial Space Act of 1998 as bolded below:

(f) REMOTE SENSING-

(1) APPLICATION CONTENTS- Section 201(b) of the ***Land Remote Sensing Policy Act*** *of 1992 (15 U.S.C. 5621(b)) is* ***amended****--*

(A) by inserting `(1)' after `NATIONAL SECURITY- '; and

(B) by adding at the end the following new paragraph:

`(2) The Secretary, within 6 months after the date of the enactment of the Commercial Space Act of 1998, shall publish in the Federal Register a complete and specific list of all information required to comprise a complete application for a license under this title. An application shall be considered complete when the applicant has provided all information required by the list most recently published in the Federal Register before the date the application was first submitted. Unless the Secretary has, within 30 days after receipt of an application, notified the applicant of information necessary to complete an application, the Secretary may not deny the application on the basis of the absence of any such information.'.

(2) NOTIFICATION OF AGREEMENTS- Section 202(b)(6) of the ***Land Remote Sensing Policy Act*** *of 1992 (15 U.S.C. 5622(b)(6)) is* ***amended*** *by inserting `significant or substantial' after `Secretary of any'.*[36]

Often, the multiplicity of CRS laws and policy documents create confusion, even for those who are acknowledged experts on CRS policy issues. For instance, in a paper written for a conference entitled "No More Secrets? Policy Implications of Commercial Remote Sensing Satellites," held by the Carnegie Endowment for International Peace on May 26, 1999, Ann Florini and/or Yahya Dehqanzada stated: "All these pressures led the U.S. Congress to pass the Land Remote Sensing Policy Act (P.L. 102-555), which was signed into law by President Clinton on October 28, 1992."[37] Unfortunately, this is yet another example of historical inaccuracies concerning U.S. CRS laws and policies. Perhaps this knowledge void manifestation was due to confusion between the 1992 Act and Presidential Decision Directive (PDD)-23, issued by the Clinton administration in 1994, but President Clinton could not have signed the Land Remote Sensing Policy Act into law in 1992 since he wasn't even elected until November of that year and did not take office until January 1993. Instead, it was President George H.W. Bush that signed the Policy Act into law on October 28, 1992.

Lack of precise knowledge of legal and policy regimes concerning CRS was also evident in J Todd Black's discussion of CRS laws and policies (see Chapter 2). According to Black, "As regards policy, the United States has been cautious. PDD-23, which placed limits on dissemination of high-resolution imagery from commercial sources [not completely true; no mention of imagery dissemination, unless shutter control is used; rather it covers systems and technology transfers], was eventually incorporated into law, in the 1992 Landsat Act [absolutely not true].”[38] First, the 1992 Act was not the “Landsat Act,” it was the “Land Remote Sensing Policy Act” and included provisions on satellite operations other than that of the Landsat satellite. Other writers, even experts on remote sensing policy issues, also tend to confuse the 1984 Act dealing with Landsat (my short title: “Commercialization Act”) and the 1992 Act (my short title: “Policy Act”).[39] Secondly, and even more telling is the fact that PDD-23 came after the 1992 Act, not before it, as sated in the article. PDD-23 was issued in 1994, whereas the Land Remote Sensing Policy Act was passed in 1992. The Act was a product of the first Bush administration, whereas PDD-23 was a product of the Clinton administration. This was akin to putting the 1994 policy cart before the 1992 legal horse.

Despite these apparent knowledge gaps, Black offered insightful glimpses into the perspective of the social and political actors on the CRS stage. Naturally, industry is interested in a “free market” approach to CRS policy, as he argues.[40] Moreover, Black was extremely prescient in predicting the employment of means to allay national security concerns over commercial high-resolution imagery falling into the wrong hands: “For example, if the United States wanted to prevent a particular type of imagery from reaching an adversary, it could offer substantially more money for the exclusive access to that imagery during a crisis.”[41] Such action actually occurred in 2001, when the then NIMA bought up all U.S. commercial high-resolution imagery of Afghanistan during Operation Enduring Freedom through an exclusive purchasing agreement with Space Imaging.

All of the foregoing examples of knowledge voids concerning CRS legal and policy regimes are important to identify, analyze, and correct, so that those interested in CRS policy issues or those charged with drafting CRS legislation, policies, and regulations get an accurate picture of this seemingly complex and difficult to understand aspect of CRS (i.e., CRS laws and policies).

Notes

1. Courtney A. Stadd and Ronald J. Birk, “No Strings Attached? Commercial remote sensing companies hope that US government policy will keep pace with the industry’s rapidly expanding needs,” *Imaging Notes* (July-August 1999); http://www.imagingnotes.com/julaug99/ja99nost.htm, accessed September 12, 2004.

2. Molly K. Macauley, statement in U.S. House of Representatives, Committee on Science, Subcommittee on Space (hearings on the “Commercialization of Space”) (May 21, 1997); http://www.house.gov/science/macauley_5-21.html, accessed June 23, 2006.

3. Vipin Gupta, “New Satellite Images for Sale,” *International Security*, Vol. 20, No. 1 (Summer 1995), 99, 100 and 115.

4. Gerald Steinberg, “Dual-Use Aspects of Commercial High-Resolution Imaging Satellites,” *Mideast Security and Policy Studies*, Vol. 37 (February 1998); original publication unavailable; digital publication on line at: http://www.biu.ac.il/SOC/besa/books/37pub.html#I, accessed November 6, 2005.

5. Molly K. Macauley and Timothy J. Brennan, “Enforcing Environmental Regulation: Implications of Remote Sensing Technology (Discussion Paper 98-33)” (Washington, DC: Resources for the Future, 1998), 11 (note 14).

6. Greg Snyder, “Commercial Remote Sensing Data Transfer Guidelines,” (briefing) in Advisory Committee for Commercial Remote Sensing (ACCRES), National Oceanic and Atmospheric Administration (NOAA), Open Session Meeting Summary [7th Meeting], September 13, 2005; http:www.accres.noaa.gov/7thMeeting09-13-05.pdf, accessed September 14, 2007.

7. Snyder, comments during briefing, Ibid.

8. Joanne Gabrynowicz, comments in Advisory Committee for Commercial Remote Sensing (ACCRES), National Oceanic and Atmospheric Administration (NOAA), Open Session Meeting Summary [7th Meeting], September 13, 2005; http://www.accres.noaa.gov/7thMeeting09-13-05.pdf, accessed September 14, 2007.

9. _____, “Interview: Understanding the Future of Commercial Remote Sensing,”*PE&RS*, Vol. 66. No. 1 (January 2000); http://www.asprs.org/publications/pers/2000journal/january/interview.html, accessed October 16, 2005.

10. Gerald Steinberg, “Dual Use Aspects of Commercial High-Resolution Imaging Satellites.”

11. _____, Manfred Lachs Space Law Moot Court Competition 2001; http://www.spacemoot.org/acrobat/2001_1R.pdf, accessed 5 Sept 05.

12. Molly K. Macauley, statement in U.S. House of Representatives, Committee on Science, Subcommittee on Space and Aeronautics (hearing on the "Commercialization of Space") May 21, 1997; http://www.house.gov/science/macauley_5-21.html, accessed June 23, 2006.

13. Stadd, Courtney A. and Ronald J. Birk, "No Strings Attached? Commercial Remote Sensing companies hope that U.S. government policy will keep pace with the industry's rapidly expanding needs," *Imaging Notes* (July/August 1999); http://ww.imagingnotes.com/julaug99/ja99nost.htm, accessed on September 4, 1999.

14. Ann M. Florini and Yahya A. Dehqanzada, "No More Secrets? Policy Implications of Commercial Remote Sensing Satellites," (working paper No. 1 prepared for a conference by the same title) (July 1999); http://www.ceip.org/programs/governance/remotesensingconf/NoMoreSecrets1.htm, accessed June 13, 2004.

15. _____, "National Space Policy," (editorial comments on the National Security Decision Directive Number 42, July 4, 1982 of the Regan administration); http://www.hq.nasa.gov/office/pao/History/ndss-42.html, accessed June 3, 2006.

16. _____, "Presidential Directives (PD) and Presidential Review Memoranda (PRM)," Atlanta, GA: Jimmy Carter Library and Museum; http://www.jimmycarterlibrary.org/documents/pddirectives/pres_directive, accessed June 3, 2006.

17. _____, "Presidential Directives (PD) [Carter Administration, 1977-81]," http://fas.org.irp/offdocts/index.html, accessed November 6, 2005.

18. _____, "NSDD-National Security Decision Directives Regan Administration," http://fas.org.irp/offdocs/index.html, accessed November 6, 2005.

19. _____, "National Security Directives (NSD) [Bush Administration, 1989-93]; http://fas.org/irp/offdocs/nsd/index.html, accessed November 6, 2005.

20. _____, "Presidential Decision Directives [PDD] Clinton Administration 1993-2000; http://fas.org/irp/offdoccs/pdd, accessed November 6, 2005.

21. _____, "National Security Presidential Directives [NSPD] George W. Bush Administration," http://fas.org.irp/offdocs/index..html, accessed November 6, 2005.

22. Corey Michael Dvorkin, "Two Steps Back: The Uncertain Promise for the Strategic Use of Commercial Satellite Imagery," in James F. Keeley and Robert N. Huebert, eds. *Commercial Satellite Imagery and UN Peacekeeping* (Burlington, VT: Ashgate Publishing Company, 2004), 151.

23. Ibid, 153.

24. Yahya A. Dehqanzada and Ann M. Florini, *Secrets for Sale: How Commercial Satellite Imagery Will Change the World* (Washington, DC: Carnegie Endowment for International Peace, 2000), 32.

25. J. Todd Black, "Commercial Satellites: Future Threats or Allies?," *Naval War College Review* (Winter 1999); http://www.nwc.navy.mil/press/Review/1999/winter/art5~w99.htm, accessed September 18, 2005.

26. Ibid.

27. See Vipin Gupta, "New Satellite Images For Sale: The Opportunities and Risks Ahead, (webpage section entitled "Policy Developments on Sale of High-Resolution Satellite Imagery); http://www.llnl.gov/csts/publications/gupta/pd.html, accessed October 2, 2005.

28. Gupta, "New Satellite Images for Sale," *International Security*, Vol. 2, No. 2 (Summer 1995), 99.

29. Ibid.

30. Ibid.

31. Richard E. Rowberg, *Commercial Remote Sensing by Satellite: Status and Issues*, Washington, DC: Congressional Research Service, Library of Congress, January 8, 2002, 15.

32. Robert Preston, "Space Remote Sensing Regulatory Landscape," in Baker, O'Connell and Williamson, 501.

33. Ibid, 507.

34. Rowberg.

35. Ibid.

36. Commercial Space Act of 1998 (P.L. 105-33), Oct 28, 1988 (see appendix D, this dissertation).

37. Florini and Dehqanzada, "No More Secrets? Policy Implications of Commercial Remote Sensing Satellites."

38. Black, 101.

39. For a clear and very detailed explanation of the two Acts, refer to Joanne Irene Gabrynowicz, "The Promise and Problems of the Land Remote Sensing Policy Act of 1992," *Space Policy*, Vol. 9, No. 4 (November 1993), 319-328.

40. Black, 106.

41. Ibid, 107.

Appendix I: High-Resolution Civil/Commercial Remote Sensing Satellite Systems (Worldwide)

Sources: Individual company websites. Also, NOAA (research by William Stoney), "World Commercial Remote Sensing Satellite Database" (as of August 9, 2006); http://www.licensing.noaa.gov/whatsnew2.html, last accessed October 28, 2007. Data also confirmed by eoPortal Directory of Resources; http://directory.eoportal.org/, last accessed October 28, 1007.

The following split-period table depicts civil and/or commercial earth observation satellites with high-resolution imaging capabilities. Here, high-resolution systems are considered to be those that provide 1-meter panchromatic and 4-meter multispectral imagery. Other more capable systems are projected to be launched in the near future but were not included on this list, since it represents absolute currency of electro-optical systems in operation. The table is divided into two periods (i.e., the period prior to July 2003) to demonstrate that the U.S. once led the global industry of CRS systems but that its lead is being cut by foreign satellite systems in just the last few years. This information is critical to U.S. legislators, policymakers, and regulators in crafting CRS control regimes that meet the USG's stated objective of promoting the U.S. CRS industry, and ostensibly keeping it competitive in the global earth observation satellite arena. Duplicate numbers indicates a close tie (in such cases, countries are ordered alphabetically). Resolution specifications are based on imaging from nadir.

MEMBERS OF THE ONE-METER OR LESS CLUB

Rank	Country	Company/ Organization	System	Pan Resolution (m)	MS Resolution (m)	Best Radar Resolution (m)
Systems Prior to June 2003						
1	USA	DigitalGlobe	QuickBird	0.6	2.4	
2	USA	Space Imaging	Ikonos	1	4	
2	USA	Orbimage	Orbview-3 (currently malfunctioning)	1	4	
Current Systems (as of November 20, 2007)						
1	USA	DigitalGlobe	WorldView-1	.45	1.8	
2	USA	DigitalGlobe	QuickBird	0.6	2.4	
3	ISRAEL	ImageSat Int'l	EROS-B	0.7		
4	INDIA	Indian Space Research Organization	Cartosat-2 (IRS-P5)	< 1		
4	RUSSIA	TsSKB Progress	Resurs-DK-1	< 1	2.4~3.5	
5	GERMANY	German Aerospace Center (DLR/Infoterra)	TerraSar-X1	n/a	n/a	1
5	ITALY	Italian Space Agency (ASI)	COSMO-Skymed-1	n/a	n/a	≤ 1
5	SOUTH KOREA	KARI	KOMPSAT-2	1	4	
5	USA	GeoEye	Ikonos	1	4	

Table I: Rankings of High-Resolution Civil/Commercial Earth Observation Satellite Firms and Systems based on Imaging Capabilities

Appendix J: Knowledge Barriers – Examples of Restricted Information Flow

Although I work in an environment that has information restrictions, I chose not to write a classified dissertation that relied in part on material or information from that environment (to include for-official-use-only information) because the majority of my committee is not cleared for such information and because it would have detracted from Virginia Tech's philosophy of information openness. I also chose not to attend any of the closed sessions of ACCRES meeting held by NOAA. These decisions were made so that the dissertation would not be subjected to a security review or possible indiscriminate censoring of policy views, which might have detracted from the generation of new knowledge that this study is supposed to provide. As a result, this dissertation will not be published or posted online for worldwide access for at least three year (with the option to extend beyond that period indefinitely or for as long as I am still working in that environment).

Even though this dissertation was based completely on open-source, publicly-available documents and information, there is another world of CRS-related information that could shed additional light on CRS policy issues and associated knowledge voids if it were not restricted or was otherwise available. Such information consists of three broad sources or categories: 1) Official, classified, or restricted USG information, 2) proprietary information held by the CRS industry, and 3) foreign information that is either unavailable, difficult to acquire, or in a non-translated form. It is important to note that the notional scenarios described below based on these three categories are strictly hypothetical and are not based on any extant information or material.

As mentioned in Chapter 4, restricted government information could offer greater insights into the threats to national security and foreign policy that are currently known and perceived by officials in defense or national security organizations. A hypothetical example of such information residing behind this knowledge barrier could be data or information on how high-resolution satellite imagery in various forms (panchromatic, multispectral, radar, etc.) can reveal (to potential adversaries to the U.S.) targets of opportunity such as troop movements, military facilities and equipment, terrain (e.g., coastlines, swamplands, forests, jungles, etc.) or other conditions (trafficability, camouflage, decoys, etc.) in areas of military operations). Such information could be useful to terrorists or conventional enemy forces attempting to inflict casualties or battle damage on U.S. forces in various theaters or areas of operation.

Obviously, this type of information tends to be closely protected and possibly not completely shared with the CRS industry to assuage its concerns over restrictive CRS policies and regulations such as shutter controls, 24-hour delay rules, and dual-tiered licensing provisions. Such hesitancy to share this type of valuable but restricted information, even if key CRS officials were cleared for such information, could be due to concerns over potential leaks of such information to the press or other uncleared individuals or organizations. Thus, it is feasible that only minimal threat information is or would be offered to CRS industry officials to achieve the goal of convincing or at least informing them that national security concerns are an integral and necessary part of current U.S. regulatory regimes for CRS. If more information of this nature was made available, it could potentially remove some knowledge gaps in the industry about the rationale for restrictive CRS licensing policies and create a greater appreciation for the challenges faced by the U.S. defense establishment due to globally available high-resolution imagery. It also could improve policy debates and negotiations.

On the foreign policy front, DOS is often in a even more difficult position from which to share sensitive information with the U.S. CRS industry to demonstrate how satellite imagery in the wrong hands could compromise U.S. foreign relations and diplomatic efforts. A hypothetical scenario in this case might be a counter-drug operation ran out of a U.S. mission in the country of Cocainalogia, which could potential be compromised should high-resolution CRS imagery of the operation be available on the word market (showing the location of U.S. raid staging forces and facilities in a jungle area of that notional country). In this notional case, the reason for DOS's concern would be that the U.S. (hypothetically) does not have official diplomatic relations with (or an embassy in) Cocainalogia, but has direct dealings with its government, which has permitted such operations. Divulgence or exposure of such closely-held operational information might hamper future convert relations and embarrass both the U.S. and Cocainalogia. DOS might like to share this information or that of a similar scenario with the CRS industry to demonstrate how its imagery data could potentially complicate official but sensitive inter-state relations. However, DOS could be reluctant to do so for fear of intentional or inadvertent leaks of such information.

The best DOS might do is to couch its briefings to the industry in the broadest and most general terms. Unfortunately, this could lead industry to surmise that provision of such scenario-based information is just a scare tactic or perhaps overblown or unrealistic fictitious situations. Real world situations tend to be more credible. Should industry have detailed information on various scenarios that could lead to its imagery complicating or compromising diplomatic operations, it might have a greater appreciation for policy stances by the foreign policy community and more importantly might be in a better position to envision or brainstorm how it could still successfully or profitably operate in such a threat environment by figuring out ways to keep such imagery out of the hands of bad actors in or out of Cocainalogia. The dilemma for U.S. policymakers in these types of cases is that sharing too much information runs the risk of compromising their operations, while sharing too little information runs the risk of not educating the CRS industry enough concerning legitimate USG concerns over the malevolent uses of CRS imagery data and products.

Sharing of proprietary data and information (belonging to individual CRS firms) is another category of knowledge barriers and is very problematic. For CRS licenses and foreign agreements, industry is obligated to provide some proprietary information and (while doing so) it is very concerned about the confidentiality of such information and about potential leaks to its competitors by government bureaucrats. Still if more proprietary information, such as business plans, technical details of CRS systems for insurance purposes, and non-public financial statements, was made available to key USG policymakers and regulators, it might narrow some knowledge gaps in the bureaucracy concerning the challenges faced by the nascent and sometime struggling CRS industry in surviving in the competitive marketplace for global CRS imagery data. Unfortunately, the fear of loss of such valuable information to competitors (domestic or foreign) is a strong barrier to the free flow of proprietary information, even to designated USG officials. Even if such information was provided in vague or highly generalized language, it might be difficult for U.S. CRS policymakers to translate the hypothetical information into reality.

The third category of knowledge barriers consists of restricted, unavailable, or hard to find foreign information on civil or CRS systems, data, programs, organizations, and business/marketing plans. Much of this type of information is likely restricted (in its country of origin) and/or in a foreign language that would be expensive or time consuming to translate. Had more of this type of information been available during research for this dissertation, it might have shed more light on the status of foreign CRS systems that serve as competition to U.S. commercial observation satellite firms. Such information could potentially demonstrate to the U.S. national security and foreign policy establishments that the stated goal of the U.S. to promote the CRS industry and keep it in the lead among worldwide civil or CRS satellite operating nations or entities is significantly challenged and complicated as long as restrictive licensing and operating guidelines are still in place.

One example of this type of information is the laws, policies, and directions (regulations) of the Republic of Korea's (ROK) space activities (of which CRS plays a part). A knowledge void concerning the existence of such documents was manifested in a recent study provided to NOAA by the National Center for Remote Sensing, Air and Space Law (NCRSASL). Specifically, that study had a table of international space laws and policies but contained no information (entries) for ROK policies and directives.[1] However, I discovered that such information does exist and notified the Center accordingly. Unfortunately, the documents were are all in Korean and would have needed to be translated into English for NOAA or USG CRS policymakers to gain insights into how the ROK envisions and implements its space activities. Being a Korean linguist, I translated portions of those documents as a courtesy to the NCRSASL but was too busy working on this dissertation to do much more at the time.

More importantly, this is just one example of many potential cases where knowledge voids about foreign CRS operations and organizations exist due to foreign language barriers. Here, the C^2RS^2 could play a role in unearthing such information, since NOAA simply doesn't have the time or sufficient budget to allow it to pursue extensive and repetitive foreign CRS information collection, exploitation, and analyses. The key for the C^2RS^2 would simply be sufficient funding to conduct such research services. Most interestingly and tellingly, the NCRSASL study mimicked key points of this appendix as it relates to knowledge and perception gaps and knowledge barriers. According to the report, "Formal law and policy is difficult to find due to differences in legal systems, language barriers, and the perceived important or lack thereof, of the subject matter."[2]

Notes

1. National Center for Remote Sensing, Air, and Space Law, The Land Remote Sensing Laws and Policies of National Government: A Global Survey, University, MS: University of Mississippi (Law School), January 3, 2007, xi; http://www.licensing.noaa.gov/NOAARemoteSensing_LawGlobalSurvey.pdf, accessed November 21, 2007.

2. Ibid, 3.

Appendix K: Vita

Kenneth P. Thompson

EDUCATION

Virginia Polytechnic Institute and State University, Falls Church, VA

Ph.D. candidate, Science and Technology Studies, 2007
Dissertation: *A Political History of U.S. Commercial Remote Sensing, 1985-2007: Conflict, Collaboration, and the Role of Knowledge in the High-Tech World of Earth Observation Satellites*

Advisor: Dr. Janet Abbate

University of Washington, Seattle, WA

M.A., East Asian Studies (Korean Regional Studies), 1978
Advisor: Dr. James B. Palais

Central Michigan University, Mt. Pleasant, MI

M.A., Management and Supervision (Business Management), 1976

University of Utah, Salt Lake City, UT

B.A., Political Science (w/Certificate in International Relations), 1971

RESEARCH INTERESTS

Contemporary technology studies, policy studies of commercial remote sensing, East Asian remote sensing satellite systems, geospatial technology, utilization of earth observation systems for international public health.

PROFESSIONAL EXPERIENCE AND MOST RECENT POSITION

CENTRA Technology, Inc., Burlington, MA

Analytic Director and Program Manager, 2002-Present

U.S. Army (32 years)

Colonel (USAR, Retired)