THE END OF SECRECY?[1]

DUAL-USE REMOTE SENSING SATELLITE TECHNOLOGY AND NATIONAL SECURITY IMPLICATIONS – A REGULATORY FRAMEWORK

Master of Arts in Law and Diplomacy Thesis

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[1] Ann M. Florini, "The End of Secrecy," *Foreign Policy*, 1998

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Abstract

This paper examines the evolution of satellite imagery in the context of two emerging trends: the information revolution and an increasing level of transparency.[1] Through a study of the historical development of technology, international policies, and emerging tenets of space law, this study observes the burgeoning industry of satellite remote sensing systems. The expansion of satellite imaging illustrates the diverse range of current and future applications of this technology. Domestic and international policies are depicted in order to highlight the *ad hoc* nature in which the current regulatory framework has evolved. This essay suggests that recent events, combined with the advent of high-resolution imagery available to the general public, have dramatically altered the manner in which the international community perceives the commercial remote sensing marketplace and products. This analysis begins with an overview of remote sensing, continues with a review of policy, space law, and the marketplace, and concludes by submitting a proposal for the creation of a regulatory framework for cooperation and oversight of remote sensing satellites.

[1] Ann M. Florini, "The End of Secrecy," *Foreign Policy*, 1998,

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ABBREVIATIONS

CEOS	Committee on Earth Observation Satellites
DOD	Department of Defense
DSCS	Defense Satellite Communications System
FLSATCOM	Fleet Satellite Communications System
FIA	Future Imagery Architecture
GEO	Geostationary Orbit
GIS	Geographic Information Systems
GPS	Global Positioning System
IAEA	International Atomic Energy Agency
IRSA	International Remote Sensing Agency *(proposed)*
ISMA	International Satellite Monitoring Agency
ITSO	International Telecommunications Satellite Organization
LEASAT	Leased Satellite
LEO	Low Earth Orbit
MEO	Medium Earth Orbit
NIMA	National Imagery and Mapping Agency
SAR	Synthetic Aperture Radar
MSS	Multi-Spectral Sensors
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NOAA	National Oceanic and Atmospheric Administration
NRO	National Reconnaissance Organization
NSDD	National Security Decision Directive
NSPD	National Space Policy Directive
PDD	Presidential Decision Directive
SHF	Super-High Frequency
SPOT	Satellite por L'Observacion de la Terre
UHF	Ultra-High Frequency
UN	United Nations
UNCOPUOS	UN Committee on Peaceful Uses of Outer Space
U.S.	United States of America
U.S.S.R.	Union of Soviet Socialist Republics
WMO	World Meteorological Organization

INTRODUCTION

"Knowledge, more than ever before, is power."[2]

In their article entitled *"America's Information Edge",* authors Joseph Nye and William Owens depict the United States as a country aided by its unparalleled ability to integrate complex information systems. They assert that the information edge multiplies American diplomatic force, allowing it to assist democratic transitions abroad, resolve regional conflicts and address threats including terrorism, crime, and the proliferation of weapons of mass destruction.[3] Central to this concept of an information edge are the underlying remote sensing technologies that enable the collection of real-time, continuous surveillance data that can be obtained in all weather conditions, both day and night, from anywhere in the world virtually instantaneously. Satellite capabilities and, more importantly, the ability for non-governmental entities to access information have opened a virtual Pandora's Box. This paper will address many of these concerns, proposing a possible framework for regulating remote sensing satellite systems globally.

A number of factors have contributed to the proliferation of commercial imagery satellites while simultaneously broadening their possible applications. These elements include: the evolution of information technologies as semiconductors and micro-processors; advances in digital signal processing; the deregulation of global telecommunications services, the allocation of new spectrums to commercial satellite systems; the advent of higher imagery resolution; the decreasing cost and increasing

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[2] Nye, Joseph S., Jr. and William Owens A., "America's Information Edge," *Foreign Affairs,* March-April 1996, 2.
[3] Id.

reliability of satellites; as well as an expanding global demand for satellite services driven by the information revolution.

Taken together, these characteristics are fueling a commercial satellite industry that is becoming both more diversified and transparent.[4] At present, satellites are used for a diverse array of tasks. These fall into three broad categories - communications, navigation, and remote sensing. Such a significant change, motivated by both fiscal and geopolitical considerations, is shifting the balance between civilian and military affairs. Currently, the United Nations (U.N.) is looking into the possibility that satellite imagery could assist ongoing efforts to curtail drug trafficking and narcotics production.[5] In addition, the International Atomic Energy Agency (IAEA) commissioned a study into the utility of high-resolution imagery for monitoring state compliance with international arms control agreements.[6] NASA also recently inquired to obtain imagery as part of its ongoing investigation into the reasoning behind the destruction of the Space Shuttle Columbia which transpired on February 1, 2003.[7] In order to more fully understand this transformation and its implications, one must look closely at the underlying dynamics.

Perhaps the most recent example of changes in government policy surrounds the war against terrorism. This effort has forced policymakers to confront the likely scenario whereby potentially sensitive information could end up in the wrong hands. In just under two years, America's response to the proliferation of information in the commercial marketplace has transformed dramatically. During the war in Afghanistan which began

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4 Yahya A. Dehqanzada and Ann M. Florini, *Secrets for Sale: How Commercial Satellite Imagery Will Change the World,* Washington, D.C.: Carnegie Endowment for International Peace, 2000, 46.
5 Vernon Loeb, "Spy satellite program faces hardship, US says," *The Boston Globe* (2002): A2.
6 Id.
7 "Shuttle Team Sought Satellite Assessment of Liftoff Damage," in *The New York Times*. New York March 13, 2003. *Available at* http://www.nytimes.com/2003/03/13/national/nationalspecial/13SHUT.htm?pagewanted=...

on October 7, 2001, the U.S. chose to enter into an assured access agreement with Space Imaging, an American commercial satellite company, granting the government exclusive rights to all images taken by its high-resolution IKONOS-2 satellite of Operation Enduring Freedom.[8] The IKONOS-2 satellite was the sole commercial high resolution satellite able to take pictures of the operational battlefield in Central Asia. The National Imagery and Mapping Administration (NIMA), having jurisdiction to purchase all remote sensing images, signed a thirty-day contract in October 2001 which was later extended for an additional month. The agreement included a $5 million supplemental payment to postpone the posting of these images onto the U.S. Geological Survey's public archive.[9] The contract allowed NIMA to approve of images prior to their being released to the general public. This policy contrasts markedly with that put forth during Operation Iraqi Freedom several months later in which no limitations were imposed on the commercial sector. Instead, the U.S. government opted to make such images of Iraq available on the open market to whoever was willing and able to purchase them. This shift in policy indicates the difficult position in which the U.S. finds itself, unable to strictly control the flow of information.

How could such a dramatic policy change transpire in a relatively short period of time? The answers to this and other questions delve into the heart of this paper's thesis: the remote sensing industry may be seen as a harbinger of the impact technological innovation has and will continue to have on the policy apparatus, military doctrine, and international legal principles embraced by the global community. The manner in which the international community chooses to confront these complex matters could go far to

[8] Anne Marie Squeo and Antonio Regalado, "Pinpoint Warfare," *The Wall Street Journal* (2003): B1-B3.
[9] Id.

serving as a model for emerging industries while ensuring confidence and stability in a fragmented post-Cold War community.

This analysis begins with an overview of the remote sensing industry, its history, technology, and range of applications. The study then turns to a discussion of the policies promulgated by the United States in the form of statutes as well as by the international community through the vehicle of both U.N. General Assembly resolutions and international agreements. Attempts made by such governments as the U.S. to try and control the dissemination and access to the information procured by advanced satellite systems will be examined followed by a discussion of the implications such regulations have on the industry. The report proceeds by outlining current international space law in the area of remote sensing technology. Upon establishing the foundation, a regulatory framework for the industry is then set forth to exemplify the potential impact the international response can have on satellite systems and remote sensing systems in particular, serving as a potential model for emerging technologies in the future.

CHAPTER ONE: ORIGINS

The concept that Earth-orbiting satellites could be utilized for the purpose of gathering information in the form of communication and imagery can be credited to Arthur C. Clark. In an article published in 1945 about the use of the German V-2 rocket, he stated the following,

> *An artificial satellite at the correct distance from Earth would make one revolution every 24 hours; i.e. it would remain stationary above the same spot and would be within optical range of nearly half the Earth's surface. Three repeater stations, 120 degrees apart in the correct orbit, could give television and microwave coverage to the entire planet.*[10]

Clark's belief was that these stations would be manned satellites situated high above the major landmasses, capable of providing direct-broadcast television. Indeed, by the 1950s, the U.S. had invested significant resources in developing imagery and communications capabilities in space. Several satellite programs have since been developed.

Optical imagery satellites began operating in the 1960s.[11] Today, the development of the satellite is believed to represent one of the most important technological advancements since the advent of thermonuclear weapons, prompted a sea change in one's perception of the Earth.[12] In recent years, the study of our planet from space has evolved from the realm of mere research to that of providing daily applications. Governments, non-governmental organizations, and individuals alike draw upon the forty-year heritage of space technology, depending heavily on satellite sensors to perform

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[10] *"Increased Military Reliance on Commercial Communications Satellites: Implications for the War Planner."* in Air War College. November 1, 1998. Available at http://research.au.af.mil/papers/student/ay1998/awc/98-138.pdf.

[11] Kevin M. O'Connell et al., "U.S. Commercial Remote Sensing Satellite Industry: An Analysis of Risks," *RAND* (2001).

[12] The term satellite is commonly used to refer to any object that revolves around another object. For the purposes of this report, satellite is specifically intended to indicate an object that revolves around the Earth.

a diverse array of tasks ranging from joint military operations, communications, surveillance, weather forecasts, crop prediction, mineral exploration, pollution detection, and directional assistance.[13]

The belief that space imagery could one day be possible originated many years prior to the launch of the first satellite. In 1858, the French photographer Gaspard-Felix Tournachon pioneered the field of remote sensing when he captured the world's first aerial photograph of Paris from his gas balloon situated 250 feet above the ground.[14] Within two years, Mr. Tournachon would find himself taking aerial pictures of enemy troop movements as part of the 1870 Franco-Prussian War.[15] During the 1860s, Jules Verne wrote about what he termed *"Lunanauts"*, devices that would observe cloud systems. By the mid-nineteenth and early twentieth centuries, cameras were being deployed aloft in balloons and Wilbur Wright had successfully piloted the first plane outfitted with a functional camera.[16] The mid-1940s saw rockets bearing cameras included as part of their payload launched into sub-orbital flight, giving rise to discussion of the possibility of realizing Mr. Verne's dream in less than a century.

Early American satellite programs began in earnest in the late 1950s, a direct response to the perceived threat presented by the successful testing by the Soviets of an intercontinental ballistic missile as well as their launch of the first man-made Earth satellite, Sputnik I, on October 4, 1957. The launch of Sputnik I precipitated a crisis of American national identity that galvanized the government and commercial industry. During the Cold War military satellites including space-based communications,

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[13] Id.
[14] Dehqanzada and Florini, *"Secrets for Sale: How Commercial Satellite Imagery Will Change the World,"* 46.
[15] Id.
[16] Id.

navigation, meteorology, early warning, and strategic intelligence were developed and deployed exclusively by both the United States and the Soviet Union, the world's only two superpowers.

Throughout the 1950s however, the United States had employed high-altitude reconnaissance aircraft to obtain imagery on the Soviet Union, Eastern Europe and China. Most notable of these planes was the U-2 spy plane. This aircraft, developed by the U.S., gathered data critical to ensuring American national security interests. Technologically, cameras employed before the deployment of the U-2 were limited to obtaining resolutions of between 7-8 meters from an approximate altitude of 33,000 feet.[17] Such a camera was far too crude for the U-2, a plane that would be operating at an approximate height of 68,000 feet. In order to be effective for intelligence purposes, the camera would need to be nearly four times as powerful.[18] Despite the emergence of technology, the U-2 was highly vulnerable to ground-based anti-aircraft missiles as demonstrated by the shooting down of the American pilot Gary Powers over the former Soviet Union in 1962. Another solution had to be explored.

Satellites were widely believed to be invulnerable, providing states with a legal, non-intrusive, and politically acceptable means of monitoring the activities of another state. Extensive resources were subsequently devoted by countries to the space industry. American investment led to the launch of Explorer I, the countries' first successful satellite, on January 31, 1958, just four months after the deployment of Sputnik into orbit. In their nascent years, the satellite programs of both the U.S. and U.S.S.R. were

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[17] Id.
[18] Id.

accompanied by a high level of secrecy with access to the images and the technology tightly restricted.

A combination of technological limitations in the development of anti-satellite systems as well as tacit agreements made between Washington and Moscow led to the underlying legitimacy of overhead reconnaissance through the use of satellites. For many years, the superpowers dominated the satellite market, employing their own systems primarily as a non-intrusive technical means of verification. By 1972, a total of ninety-four satellites had been launched successfully into space orbit.[19]

By the mid-1970s, satellites had evolved into key instruments of verification, laying the foundation for the first stages of confidence building and information exchanges between the superpowers. Both the 1972 Treaty between the U.S. and the U.S.S.R. on the Reduction and Limitation of Strategic Offensive Arms (START), and the Anti-Ballistic Missile Treaty (ABM) agreements included provisions prohibiting either country from interfering with each other's satellite systems, a provision essential to ensuring that each country possessed the capability of obtaining the necessary information to ensure that the opposing side was in compliance. These measures reduced the likelihood of miscalculation and afforded the superpowers a way to achieve transparency while avoiding instability and conflict.[20]

The fall of the Soviet Union in 1991 prompted the U.S. to undertake a comprehensive reevaluation of both its domestic and foreign policy. Signifying the end

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[19] "Dual-Use Aspects of Commercial High-Resolution Imaging Satellites." in *Mideast Security and Policy Studies*. Available at http://www.biu.ac.il/soc/besa/books/37pub.html.

[20] Transparency, as defined, is a condition in which information about government preferences, intentions and capabilities are made readily available and a condition of openness results that is enhanced by any mechanism that leads to the public disclosure of information. (From Power and Conflict in the Age of Transparency, Ch. 8).

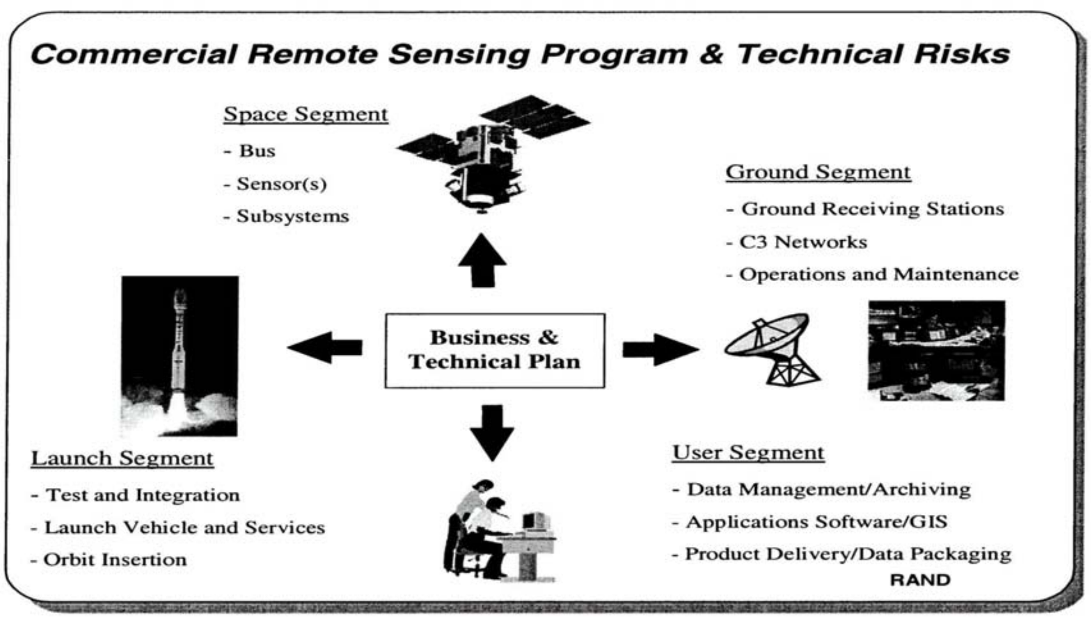
of the Cold War, this shift significantly weakened previously existing limitations and regulatory mechanisms that had been put in place to ensure proper behavior. Within the United States' policy establishment, the budget came to include a significant reduction in the amount of resources allocated to defense (See Table 6). This reapportionment of funds, combined with new government policies, spurred the involvement of the commercial sector in producing satellite images. Such an increase in overall dependency on commercial satellites has since dramatically impacted American policy.

CHAPTER TWO: REMOTE SENSING TECHNOLOGY

Remote sensing is defined as any observation made at a point removed from the object under investigation.[21] The term is given to the technique of measuring information about a subject of interest without coming into direct contact with it. This endeavor commonly refers to observations of land and water covering the Earth taken by either an airplane or a satellite.

Commercial remote sensing systems are comprised of four segments: the space, launch, ground, and user pieces (See Figure A).

FIGURE A: SEGMENTS OF COMMERCIAL REMOTE SENSING SYSTEMS[22]



[21] Richard E. Rowberg, *"Commercial Remote Sensing by Satellite: Status and Issues,"* Congressional Research Service, Report No. RL31218 (2002).
[22] O'Connell et al., *"U.S. Commercial Remote Sensing Satellite Industry: An Analysis of Risks,"* March 6, 2002.

I.) Resolution

A satellite image is a mosaic whereby a sensor applies one value (a shade of gray or a color) to each square. For a satellite with a 1-meter resolution, each square in the mosaic corresponds to one square meter of ground area.[23]

One of the most important features pertaining to satellite imagery is that of resolution which is defined as *"the area on the ground that a single pixel (a light-sensitive picture element) sees at a given instant."*[24] Resolution is measured in terms of what can be distinguished on the ground, typically in meters.[25] There are four measures of resolution. The first, spectral resolution measures the narrowness of the spectral band that can be determined. Temporal resolution indicates the frequency at which data of the same region may be obtained. Radiometric resolution measures how many levels of gray may be determined on a black and white image. Finally, spatial resolution is dependent on the optical system used to collect the reflected radiation, giving the smallest dimension an object can have while still being capable of detection by other objects.[26]

Current satellite systems measure resolution in meters, the ability to focus on a particular area and be able to identify specific details within that range (See Tables 1 and 2). Systems being used by the military are estimated to have much higher resolution capabilities. However, few countries have access to such capabilities. Those that do are oftentimes not willing to share this information with others due to its sensitive nature.

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[23] Dehqanzada and Florini, *"Secrets for Sale: How Commercial Satellite Imagery Will Change the World"*.
[24] Ann M. Florini and Yahya Dehqanzada, "Commercial Satellite Imagery Comes of Age," *Issues in Science and Technology Online* (2001)
[25] Spatial or ground resolution refers to the size of the object on the ground that a sensor is able to distinguish accurately.
[26] Dehqanzada and Florini, *"Secrets for Sale: How Commercial Satellite Imagery Will Change the World"*.

TABLE 1: ADVANCED COMMERCIAL REMOTE SENSING SYSTEMS[27]

Name	**Source**	**Status**	**Resolution**
IKONOS-2	U.S. (Space Imaging)	Operational	Pan=1m; MS=4m
OrbView-3, 4	U.S. (OrbImage)	Operational	Pan=1m; MS=4m; HS=8m
SPOT 4	France (SPOT Image)	Operational	Pan=10m; MS=20m
SPOT 5	France (SPOT Image)	Operational	Pan=2.5m; MS=10m
IRS-1C and 1D	India (ISRO)	Operational	Pan=5.8m; MS=23m
CARTOSAT 1	India	Operational	Pan=2.5m
SPIN-2	Russia and U.S.	Operational	Pan=2m
EROS A and B	Israel and Partners	Operational	Pan=1.8m and Pan=.82m
CBERS-2	Brazil/China	Operational	MS=20m
RADARSAT 1/2	Canada	2003	Radar: 1=8-100m; 2-3-100m
ALOS	Japan	2003	Pan=2.5m; MS=4m; Radar=10m

The launch of the Landsat-1 system in 1972 by the U.S. signaled the advent of providing access to observation satellites for civilian purposes. Through the 1980s and 1990s, the majority of satellite analysis available for commercial use possessed resolutions of between 5 and 30 meters. Since 1999, 1-meter images have been made commercially available from Space Imaging Incorporated's IKONOS satellite. One-meter images from other companies are just now reaching the market, including EarthWatch Incorporated's anticipated launch of its QuickBird 2 later this year which will have a 2-foot resolution and Space Imaging's launch of a 0.5-meter resolution satellite in 2004.

High-resolution commercial satellites, although less capable than current military imaging satellites, are supplemented by the usage of Geographical Information Systems (GIS) which provide three-dimensional graphical overlays for comprehensive analysis,

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[27] Derek D. Smith, "A Double-Edged Sword: Controlling the Proliferation of Dual-Use Satellite Systems," *National Security Studies Quarterly*, Spring 2001, 2.

enabling one to identify specific characteristics on the ground (See Table 2). New opportunities for governments and non-state actors alike are being created while increasing the degree of transparency. As governments continue to promote commercial involvement in outer space, these trends will continue.

II.) Sensors

Currently, civilian and commercial satellites possess one of three types of sensors: film, electro-optical or synthetic aperture radar (SAR).[28] Film sensors take actual photographs. The exposed film is then returned to Earth either by the retrieval of ejected film capsules or by recovering the satellite in its entirety. Film provides decent resolution but has two significant drawbacks: it can be slow and, once the satellite runs out of film, it becomes useless, necessitating launches of additional satellites.

A second type of sensor is electro-optical. These devices measure the electromagnetic radiation reflected off of or are emitted by objects on the Earth's surface. Once captured, digital images are then sent to receiving stations within minutes. Similar to film, these systems do not produce their own signals but rather depend largely on such sources of energy as the sun to illuminate observed objects. These systems are therefore confined to daylight operation and favorable weather conditions.

The third sensor is synthetic aperture radar sensors or SAR. SAR systems transmit a signal in the microwave component of the spectrum of the Earth's surface, detecting the characteristics of the return signal after it reflects off of an object. Due to the fact that radar satellites emit their own signals and operate in longer wavelengths, they are fully functional any time of day or night. Much like electro-optical systems,

[28] Florini and Dehqanzada, *"Commercial Satellite Imagery Comes of Age,"* November 15, 2001.

radar satellites manufacture information digitally that is then downloaded to receiving stations on Earth.[29]

III.) Active/Passive Sensing

Remote sensing involves the collection of an image of a region on Earth by either passive or active means. The former, passive sensing, is the mode of operation utilized by the majority of remote sensing satellites today. These objects monitor the area under investigation by using electro-optic sensors to collect solar radiation. As not all the spectrum passes through the Earth's atmosphere however, these sensors must be designed to receive those portions that penetrate the atmosphere. The nature of the object from which the radiation reflects determines where in the spectrum it lies. Subsequently, different features such as vegetation, water and entire metropolitan cities emit different spectral signatures. Remote sensing systems can therefore be designed for detailed study of many aspects and characteristics of the planet including atmospheric temperature and water vapor content.

Remote sensing satellites are classified as either panchromatic (PAN), multispectral (MS) or hyperspectral. PAN satellites detect energy reflectance in only one band of the electromagnetic spectrum. Thus, they produce black and white images. MS sensors can measure such reflectance in several different color bands and are therefore presented in color. These sensors allow observers to study the characteristics of features on the Earth's surface. Lastly, hyperspectral sensors image objects by using numerous different spectral bands. This technology is able to distinguish between tens and sometimes hundreds of different shades of color. Doing so enables hyperspectral sensors

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[29] Dehqanzada and Florini, *"Secrets for Sale: How Commercial Satellite Imagery Will Change the World"*.

to provide a great deal of information about the composition of features on the Earth's surface that are otherwise not discernible by either PAN or MS instruments.[30]

The latter type of remote sensing systems, termed active systems, primarily utilizes radar as the source of electromagnetic radiation. This has two advantages: it is able to penetrate cloud cover and may be used during the night due to the fact that it does not need the sun to operate. On the other hand however, radar observations are much more complex, costly, and slower to develop.

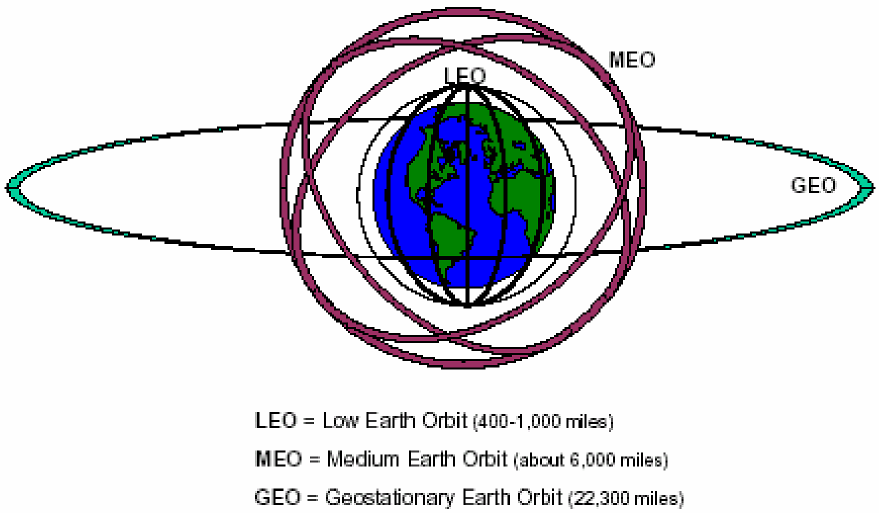
Finally, in addition to the technologies employed for obtaining images, one must acknowledge the important aspect played by raw images to facilitate the analysis and application of the data. This is deemed a value-added step consisting of software analysis systems.

IV.) Orbits

Prior to being able to formulate an accurate picture of the technological capabilities that are made possible by satellite systems, it is first necessary to look at the different orbits in which these devices function. Satellites operate in three basic orbits - Low Earth Orbit (LEO), Medium Earth Orbit (MEO), and Geostationary Orbit (GEO). The time it takes for a single orbit to be completed depends on the height of the orbit, i.e. the distance of the object from the center of the Earth. In other words, the closer an object is to the center of the Earth, the faster it is forced to travel in order to maintain its orbit and vice versa (See Figure B).

[30] Id.

FIGURE B: TYPES OF ORBITS:[31]



Satellites in the first orbital classification, LEO, operate between 400 and 1,600 miles above the surface of the Earth.[32] Due to their being situated so close to the Earth's atmosphere, these satellites must travel at an extremely high speed, 17,000 miles per hour in order to avoid the gravitational pull of the atmosphere.[33] As a result, these satellites are able to circle Earth in just ninety minutes. Most satellites in LEO travel in a circular fashion and require frequent propulsion to maintain proper altitude. The direction of LEO orbits can either be east-west or north-south in a so-called polar orbit. The polar orbit is useful because, one can eventually scan the entire planet section-by-section given the constant variation in the tilt of the Earth's axis. Satellites that operate in a polar orbit include meteorological devices and other remote sensing constellations. LEO is useful due to its being in close proximity to the Earth's surface, able to gather images with

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[31] Ashpole, Virginia B., Major, *"Command and Control 2010: The Impact of Emerging Commercial Satellite Systems on Joint Operations,"* (1998).
[32] Id.
[33] Jones, Duane A., Colonel, USAF, *"Increased Military Reliance on Commercial Communications Satellites: Implications for the War Planner."*

extreme detail. As LEO satellites are also the least expensive to operate, this area is becoming crowded with devices. Recent estimates made by the United States Space Command identify more than 8,000 objects larger than a softball currently circling the globe.[34]

Satellites in the second, intermediate orbital class, so-called MEO satellites, operate anywhere between 930 and 6,800 miles above the Earth.[35] Given their higher orbit, only ten satellites are needed to provide for full global coverage.[36] Devices orbiting in MEO offer a middle-ground between LEO and GEO and are typically occupied by satellite systems that perform either medium-range imagery or limited communication services.

Finally, GEO satellite systems are situated directly above the equator, 22,300 miles high, nearly three times the diameter of Earth.[37] At that distance the object appears to stand still despite traveling at approximately 6,800 miles per hour. It takes a full 24 hours for a device located in GEO to fully complete a single orbit, the same time it takes for the Earth to complete a spin on its axis.[38] In essence, as the GEO satellite remains directly over the same point on Earth, the two move in tandem. Due to this unique characteristic, Geostationary Orbits are also termed Geosynchronous. Because these satellites are located at an extreme distance from the surface of the Earth, they provide a broader perspective. Indeed, all of North America can be covered by just one GEO

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[34] Id.
[35] Id.
[36] Id.
[37] Ashpole, Virginia B., Major, *"Command and Control 2010: The Impact of Emerging Commercial Satellite Systems on Joint Operations."*
[38] Id.

satellite.[39] Despite their providing greater coverage of the Earth's surface, GEO devices have higher launch costs, a figure which correlates directly to the reaching of a higher orbit. Moreover, various time delays or *"latency"* periods account for the time it takes for signals to be transmitted between Earth and the orbiting satellite.[40]

Both LEO and MEO satellites have orbits which are closer to the Earth and therefore cheaper to both launch and operate. However, given that these satellites have a limited field of view, it becomes necessary to have multiple satellites in place that are sufficiently intelligent so as to pass a user from one satellite to the next as they move overhead. This element adds cost and complexity to the satellite system while reducing the signal path loss, thus requiring smaller, less expensive ground receiver equipment. MEO systems offer a middle ground between the GEO and LEO systems when accounting for such tradeoffs as constellation size, latency, power, and antenna size.[41]

V.) Image Generation

Although initial satellites recorded their images on actual film, current technologies do so via digital images that can be transmitted to stations on the ground and subsequently processed on computers. Several forms of remote sensing are presently being employed. Together, these systems provide imagery, positioning, as well as up-to-date weather information to consumers. In all, remote sensing systems depend upon the radiation source, the path of transmission, the object being observed, and the sensor used.[42]

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39 Jones, Duane A., Colonel, USAF., *"Increased Military Reliance on Commercial Communications Satellites: Implications for the War Planner."*

40 Ashpole, Virginia B., Major, *"Command and Control 2010: The Impact of Emerging Commercial Satellite Systems on Joint Operations."*

41 Id.

42 Maurice N. Andem, *International Legal Problems in the Peaceful Exploration and Use of Outer Space,* Rovaniemi, Finland: University of Lapland Publications, 1992, 511.

Including simple photography, remote sensing systems are based on the detection and documentation of electromagnetic radiation that is either emitted or reflected by the Earth's surface. The wavelength characteristics of this radiation are a function of the temperature of the energy source and can be detected by spectral sensors designed to receive the full range of values specific to that material. Depending on which part of the electromagnetic spectrum the signal occupies, it can be detected by a multitude of sensors. For example, the spectral signature of visible light to the human eye is recorded by black-and-white photographic film, while light in the near infrared and thermal infrared portions are recorded on color infrared film and thermal scanners.[43]

Multi-spectral scanners (MSS) record a wide range of electromagnetic energy including ultraviolet, visible, infrared, and thermal radiation. In addition, they detect both emitted and reflected energy electronically rather than photographically, converting the signal to digital form for image processing and interpretation. Pictures are then able to record these variations chemically on light-sensitive film.

A.) U.S. Satellite Systems – Communications, Navigation, and Imagery

1.) Landsat

Landsat is a civil remote-sensing satellite system initially built and operated by the National Aeronautics and Space Administration (NASA). Control over the system has since been transferred to the National Oceanographic and Atmospheric Association (NOAA) within the Department of Commerce. In 1985, the government privatized the program and placed responsibility for it in the hands of the Earth Observation Satellite Company (EOSAT) which operates the system today. During the 1990-91 Gulf War,

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[43] Jones, Duane A., Colonel, USAF., *"Increased Military Reliance on Commercial Communications Satellites: Implications for the War Planner."*

Landsat provided between $5-6 million worth of commercial imagery to the Department of Defense (DOD).[44]

2.) Defense Satellite Communications System (DSCS)

The first practical communications system employed in space was the Defense Satellite Communications System (DSCS). Launched in 1967, DSCS I provided a secure means of communications to a variety of customers including the White House for Presidential communications, World Wide Military Command and Control System, the Joint Chiefs of Staff, the Defense Information Service, early warning sites, intelligence sources, diplomatic data, and voice, Navy ship to shore, England and the North Atlantic Treaty Organization (NATO).[45] DSCS I consisted of twenty-six satellites traveling in GEO, each weighing less than 100 pounds.[46]

Launched in 1971, DSCS II included the same basic capabilities as found in DSCS I but with added capacity. DSCS II satellites had provisions for satellite repositioning while in orbit. A total of fifteen DCSC II were launched with eleven reaching useable orbits. The remaining devices were either destroyed or placed in unusable orbits.[47]

In 1982, the United States military launched DSCS III, the first in the series to offer anti-jamming capabilities and improved communication security. To-date, seven of the DSCS III satellites have been launched, all successfully, and remain in active service. The DSCS III system provides the majority of communication for DOD with each

44 Smith, "A Double-Edged Sword: Controlling the Proliferation of Dual-Use Satellite Systems," 31-68.
45 Ashpole, Virginia B., Major, "Command and Control 2010: The Impact of Emerging Commercial Satellite Systems on Joint Operations,"
46 Id.
47 Jones, Duane A., Colonel, USAF., "Increased Military Reliance on Commercial Communications Satellites: Implications for the War Planner."

individual satellite weighing approximately 5,765 pounds, indicative of the advanced capabilities on board each individual device.[48]

3.) Fleet Satellite Communications System (FLSATCOM)

The Fleet Satellite Communications System (FLSATCOM) was an effort undertaken by the Navy in 1978 to provide both ultra-high frequency (UHF) and super-high frequency (SHF) transponders for high-priority communications between naval aircraft, ships, submarines, and ground stations. Using the satellites in conjunction with the Air Force, this constellation provided command and control of U.S. nuclear forces. Of the initial eight satellites launched as part of FLSATCOM, only four remain, two of which are in service and two in reserve.[49]

4.) Leased Satellite (LEASAT)

Leased Satellite (LEASAT) was a program initiated in response to Congressional reviews conducted in 1976 and 1977. The review recommended an increased use of leased commercial facilities by the government. LEASAT was intended to augment FLSATCOM. Owned by Hughes Communications, the satellites were designed to provide global Ultra-High Frequency (UHF) communications to air, sea and ground forces. Its primary user was and continues to be the Navy which pays Hughes for each individual operating satellite.

Beginning in 1984, five LEASATs were launched in LEO. After initial placement, an attached inertial upper stage booster situated on the satellites placed them

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[48] Id.
[49] Id.

in permanent geostationary orbit. Taken together, FLSATCOM and LEASAT constellations today account for nearly 90% of Naval communications overall.[50]

5.) Global Positioning System (GPS)

The Global Positioning System (GPS) was begun by the U.S. military in 1965 but did not become fully operational until 1995. GPS provides consumers with highly accurate and reliable positioning, navigation, and timing information. Consisting of a constellation of twenty-four satellites accompanied by corresponding ground systems, GPS is designed to transmit continuous and precise timing signals from orbiting satellites. The devices emit two types of signals – precision and general. Initially intended to provide the armed forces with navigation and precise coordinates, today it has evolved into a case study to illustrate the proliferation of commercial applications in the marketplace. In this instance, technology developed by DOD spawned an entirely new range of public services. GPS currently serves as an information resource providing a full range of civil, scientific, and commercial functions with precision location and timing information. The market for civilian applications has since boomed, exceeding expenditures made by the military by a ratio of 8 to 1, according to the GPS Industry Council.[51]

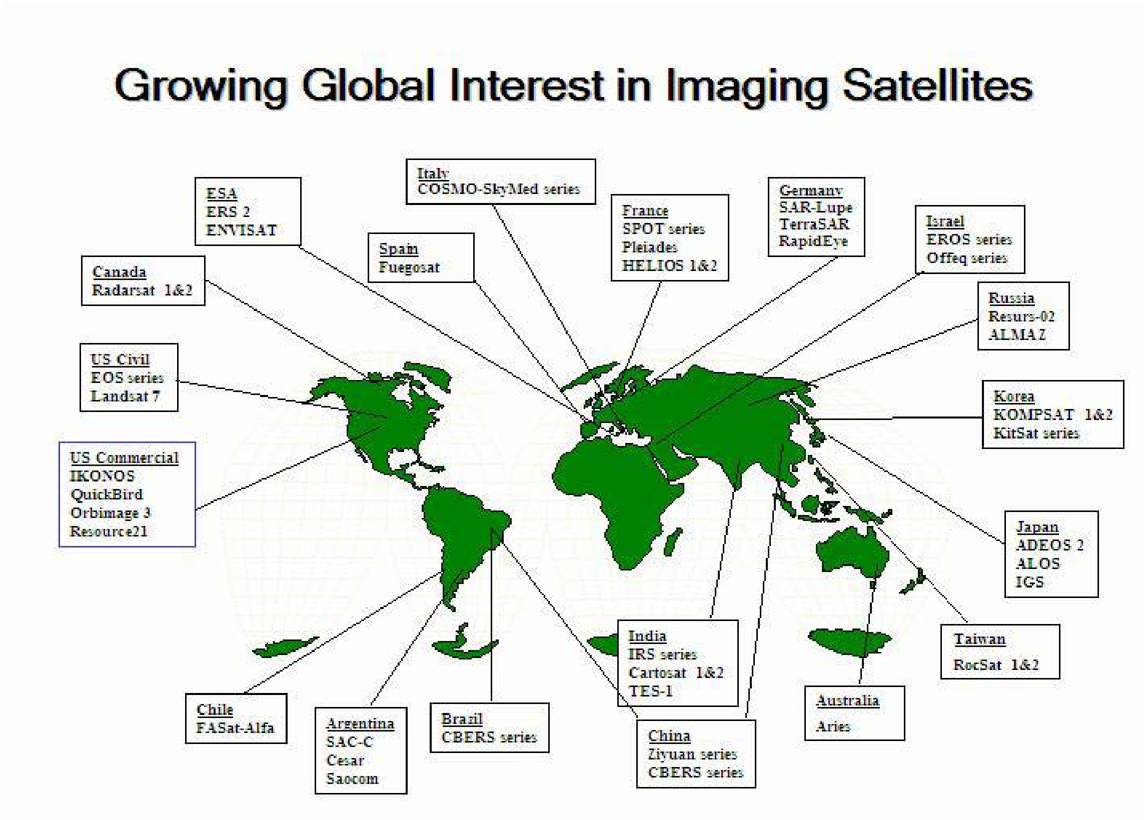
VI.) Capabilities – Other Countries

Presently, other entities are operating or pursuing their own GPS systems. These include Russia which currently operates a rudimentary GPS system and the European Union which is developing its own constellation, called Galileo that is expected to compete with GPS as part of the so-called Global Navigation Satellite Structure or

[50] Id.
[51] Data derived from study conducted by GPS Industry Council.

GNSS. Nearly forty countries worldwide have a satellite system in place. By 2005, more than twenty nations plan to launch their own remote sensing satellites.[52] Countries with some of the most advanced programs are described briefly (See Figure C).

FIGURE C



A.) *Russia*

In 1992, shortly after the collapse of the communist government, the Soviet Union began selling high-resolution imagery on the commercial market. Reportedly, its remote sensing satellites are capable of 1-meter resolution. According to the Russian government, the electro-optic cameras aboard its satellites can cover 60,000 sq. km. of

52 Linda L. Haller and Melvin S. Sakazaki, *"Commercial Space and United States National Security,"* (2000).

the earth's surface with a single picture.[53] At present, most Russian devices are neglected and remain in disrepair due to the financial inability of the country to maintain the systems already in place and to invest in research and development.

B.) China

Following the American and Russian space programs, China possesses the most advanced space industry. Since launching its first satellite in 1970, China has expanded its space program. Currently, it has developed a significant number of launch vehicles and communications, weather, scientific, and recoverable satellites. The country is also likely to become the third nation (after the Soviet Union and the United States) to launch a human into space, using its Shen Zhou spacecraft. Chinese civilian space activities are managed by both the Chinese National Space Administration and the China Aerospace Corporation, both of which were established in June 1993 and share responsibility for policy-formulation and implementation. Its commercial activities are handled by the China Great Wall Industry Corporation.

C.) Japan

The Japanese government views satellites and commercial imagery as a growth industry. It has supported the development of indigenous satellite technologies despite its continued purchasing of images from foreign competitors. Although Japanese satellites on average cost 50% more than similar U.S. satellite systems, it continues to fund the satellite projects of domestic companies.[54] Today, Japan has successfully developed an advanced space program that includes launching capabilities. Their first imaging system,

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[53] Id.
[54] Id.

designated JERS-1, was launched in 1992 and has a resolution of 18 meters. Since that time, Japan has launched several additional advanced satellite systems including the Advanced Earth Observing Satellite and the National Space Development Agency, which is able to provide a panchromatic resolution of 7.5 meters.

D.) India

At present, among the emerging space powers, India has the most active and advanced space program.[55] Through its Indian Space Research Organization, established in 1972, the populous country has placed a high priority on developing its indigenous satellite capability. Following its first successful launch in 1987, India sent four Indian Remote Sensing satellites into orbit. Its most advanced device is capable of producing panchromatic images at 6-meter resolution. India's commercial activities include distribution relationships with EOSAT and Euromap. Recently, in an effort to demonstrate the importance of remote sensing to its government, India allocated an additional $1 billion for space research.[56]

E.) Israel

Founded in 1983, the Israeli Space Agency, has conducted a significant amount of research as well as sponsoring joint endeavors with both American and European partners in civil space. Currently, Israel is developing its Eros satellite program together with West Indian Space which will have resolution capabilities of 1-meter in panchromatic range.[57] Though its total budget is a relatively small $6 million, it is important to note

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[55] Steinberg, *"Dual-Use Aspects of Commercial High-Resolution Imaging Satellites."*
[56] Haller and Sakazaki, *"Commercial Space and United States National Security."*
[57] Id.

that this figure does not include the funds dedicated to the country's other two satellite programs – Ofeq and Amos.[58]

F.) Brazil

The Group of Organizations of the National Commission of Space Activities was created in 1961 to provide Brazil with the necessary infrastructure to explore outer space. In 1981, the government formally created the Brazilian Complete Space Mission to achieve self-sufficiency in space programs.[59] More recently, in 1988, Brazil established a joint program with China to cooperate on the development of an earth resources satellite. In October 1999, the two countries jointly launched the ZY-1 satellite with 20-meter resolution and, in 2000, the ZY-2 satellite.[60]

G.) France

France is a strong foreign player in the remote sensing satellite industry. In 1982, with cooperation from Belgium, the French space agency Centre National d'Etudes Spatiales developed the SPOT Image system (Satellite por L'Observacion de la Terre). Currently, the SPOT program includes satellites capable of providing panchromatic images at 10-meter resolution, sensors for agriculture and biosphere applications, and an optical terminal capable of providing inter-satellite laser connectivity.[61] SPOT Image is arguably the world's leading supplier of geographic information from optical and Earth observation satellites, providing the bulk of its products to military customers.

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[58] Steinberg, *"Dual-Use Aspects of Commercial High-Resolution Imaging Satellites."*
[59] Id.
[60] Haller and Sakazaki, *"Commercial Space and United States National Security."*
[61] Id.

CHAPTER THREE: POLICY AND CONTROL

On December 24, 1997, a modified Russian SS-25 intercontinental ballistic missile took off from the Svobodny Cosmodrome in eastern Siberia.[62] Designed to deliver a single thermonuclear weapon, this particular rocket was instead carrying the payload of an American-made imaging satellite. The owner of the satellite, EarthWatch, Inc. of Longmont, Colorado, had contracted with Russia to boost its EarlyBird I spacecraft into polar orbit.[63] This development demonstrates how far-reaching the post-Cold War geopolitical reality has altered from its previous days and the corresponding rise in importance of economics.

I.) United States

Procurement and utilization of space-based technologically in the U.S. has historically been perceived as an activity dominated by the military. Over the past thirty years however, the commercial satellite industry has evolved into a formidable entity. The result has been a remarkable infusion of private capital into space and space-related industries, one driven by marked changes in government policy.

Such a profound economic shift is the product of incremental policies at both the national and international level. Together, these modifications have cultivated commercial technologies, fostering their development and utilization by both state and non-state actors. To understand the environment that exists today, one must first examine

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[62] *"Sentinals Rising: Commercial High-Resolution Satellite Imagery and its Implications for US National Security,"* in Air War College. *Available at* http://www.airpower.maxwell.af.mil/airchronicles/apj/apj98/win98/grund.pdf.
[63] Id.

the evolution of past policies, placing primary emphasis on documents that are relevant to civil-military affairs.[64]

The following paragraphs highlight some of the policies that account for the rise in importance of the remote sensing commercial sector.

A.) National Aeronautics and Space Act of 1958 (NASA Act)[65]

Passed shortly after the Soviet launch of Sputnik, the United States Rocket and Satellite Panel called for a National Space Establishment that did not depend entirely on military appropriations. The measure explicitly established, in law and in policy, the principle that a civilian agency would eventually play a dominant role in the development of space-based systems and technologies.

B.) Communications Satellite Act of 1962[66]

This legislation formally recognized commercial satellite communications, the oldest commercial space activity. It established an operational communications satellite system that provided a global view of how to use outer space. This marked the beginning of the satellite communications era, establishing both the Communications Satellite Corporation (COMSAT) and the International Telecommunications Satellite Consortium (INTELSAT).

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64 Miller, Dennis M., Lt. Colonel, USAF and Stocker, John, E., III, Lt. Colonel, USAF., *Commercialization of Space Systems: Policy Implications for the United States.* U.S. Naval War College, Center for Naval Warfare Strategies, 2001.

65 Public Law No. 85-868 (1958).

66 47 U.S.C. 701 (1962).

C.) National Security Decision Directive No. 42 (NSDD-42)[67]

Referred to as the *"National Space Policy"*, this directive was issued by President Reagan in 1982. The document incorporated recommendations made by a comprehensive review of space policy, establishing the National Security Council's Senior Interagency Group as the primary forum for the formulation of national space policy. Under this law, the U.S. government was instructed to conduct civil space programs in an effort to expand our knowledge of the Earth, its environment, the solar system, the universe as well as to further America's domestic and foreign policy objectives. NSDD-42 officially authorized private sector space activities and brought the field of civil operational remote sensing under the purview of the Department of Commerce.

D.) Land Remote-Sensing Commercialization Act of 1984[68]

Passage of this legislation formalized U.S. commercial space policy. It was intended to outline the terms for transferring the government-owned Landsat satellite program to the private sector. This bill addressed the essential principle ensuring the unrestricted ability of imagery satellites to fly over sovereign territory unencumbered, a vital tenet for the proper verification of arms control agreements formulated during the Cold War.

E.) National Space Policy Directives and Executive Charter (NSPD-1)[69]

NSPD-1 brought U.S. space activities under the purview of three separate sectors – civil, national security, and, for the first time, a formal commercial sector. According

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[67] National Space Policy, National Security Decision Directive No. 42, July 4, 1982.
[68] 15 U.S.C. 82 (1982)
[69] National Space Policy Directives and Executive Charter No. 1, July 4, 1982.

to this policy, the government was not precluded from the continued development of a separate, non-governmental commercial sector. Rather, governmental space sectors were encouraged to purchase commercially available space goods and services and were discouraged from competing in areas of development that could potentially have commercial applications.

F.) Commercial Space Policy Guidelines (NSPD-3)[70]

In February 1991, Congress promulgated guidelines governing commercial space systems. This policy was intended to spur the commercial use and exploitation of space technologies and systems for both economic and technological purposes. Designed to help private sector firms by establishing stable policies for dealing with the government, these principles were written to encourage the growth of the commercial space sector without direct federal subsidies. It was anticipated that this change would allow the government to fully utilize commercially available space products and services while ensuring the capacity of the commercial sector to operate autonomously.

G.) Land Remote Sensing Policy Act of 1992[71]

This legislation represents primary U.S. government authority for licensing private American firms are interested in acquiring and operating commercial observation satellites. Enactment of this measure set the foundation for commercial operation of remote-sensing systems. The act permits companies to apply to the Department of Commerce for licenses to build and operate systems and includes directives to assist in

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[70] U.S. Commercial Space Policy Guidelines, NSPD-3, February 11, 1991.
[71] Remote Sensing, P.L. 102-555, sec. 2 and sec. 201 (1992).

the tracking of data. In addition, the act authorizes the government to cut off or restrict information during times of crisis or conflict, a policy termed shutter control.

H.) Foreign Access to Remote Sensing Space Capabilities (PDD-23)[72]

Issued by President Clinton in March 1994, PDD-23 sets forth government guidelines for the remote sensing industry. It also represented the vehicle which spurred the growth of the commercial satellite market. The document was intended to strike a balance between economic and security interests by loosening restrictions on imagery sales while adding specific safeguards against its misuse.[73] The central tenet of this policy, as taken from the unclassified version of its fact sheet was *"to support and enhance U.S. industrial competitiveness in the field of remote sensing space capabilities while at the same time protecting U.S. national security and foreign policy interests."*[74] The document allowed private firms to develop, launch and sell high-resolution satellite imaging services and removed many of the uncertainties that were believe to have inhibited the development of commercial remote sensing enterprises. Among the safeguards instituted by PDD-23 included requiring export licenses, a record of satellite tasking, encryption devices, as well as a data downlink compatible with the U.S. government.[75] Predictably, as imagery already available on the market was presumed to have a favorable licensing decision, a marked increase in the number of licenses awarded to companies operating commercial satellites followed the President's declaration. However, translating the objectives of PDD-23 into actionable policies proved to be

[72] Foreign Access to Remote Sensing Capabilities, PDD-23, March 10, 1994.
[73] Smith, *"A Double-Edged Sword: Controlling the Proliferation of Dual-Use Satellite Systems,"* 31-68.
[74] The White House Office of the Press Secretary, *Foreign Access to Remote Sensing Space Capabilities Fact Sheet*, 10 March 1994.
[75] Id.

difficult given the myriad roles played by the U.S. government including its serving as regulator, customer, patron, and potential competitor of public firms.

I.) National Space Policy[76]

In September 1996, President Clinton signed the National Space Policy. This document expanded PDD-23, providing the framework for greater cooperation between the civil, commercial, intelligence, and military space programs. Its underlying principle was the belief that, in order for the United States to maintain a technological edge, it must lay out clear strategies and policies that integrate military policy and doctrine for all facets of military operations. In addition, the policy restates America's commitment to the exploration and use of outer space by all nations for peaceful purposes. Lastly, the document reiterated American support for its commercial sector by implementing principles indicating how this should be attained without sacrificing either the country's national security or its technological interests at-large.

J.) National Space Policy Review (NSPD-15)[77]

Spurred by the events of September 11, 2001 and the subsequent war against terrorism, on June 28, 2002, the Bush Administration directed the National Security Council (NSC) to undertake a wholesale reevaluation of the country's current space-based policy. The text of the measure tasks the NSC to work closely with the Office of Science and Technology Space Policy Coordinating Committee to devise a comprehensive reassessment of American policy and to propose both policy changes and recommendations to the President. At the time of this analysis, the study is ongoing and

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[76] National Science and Technical Council, National Space Policy, September 19, 1996.
[77] National Space Policy Review, NSPD-15, June 28, 2002.

reflects continued involvement on the issue of remote sensing by the United States at the highest level of the federal government.

As the United States' defense budget has been dramatically increased since the terrorist attacks of nearly two years ago, the development of high-resolution satellite imaging systems is seen as a way to augment existing defense satellite assets. Commercial remote sensing maintains its status as recipient of extensive governmental support which uses their capabilities to perform substantial but less sensitive tasks. Doing so enables military systems to concentrate solely on performing essential matters of the highest national security concern.

II.) Who controls satellite imagery?

The recent diffusion of ownership over satellite networks has prompted many to ask - who controls the information? In its policy, the U.S. government has embedded several methods of control over the flow of information. Although these concepts have been modified in response to changes in the geopolitical and technological environment, the basic tenets that originally underlined the concepts remain today.

A.) Shutter Control

In an effort to manage the attendant risks posed by satellites to U.S. national security interests, both the Land Remote Sensing Act of 1992 as well as PDD-23 were instituted, in part, to counter potential threats. These policies rely on the government's ability to restrict data collection and/or dissemination. Termed *"shutter control"*, this controversial policy is intended to address the issues of operational security and force protection, allowing the government either to black out a specific geographic area for an indefinite period of time or to prevent technologies with a certain resolution from going online for commercial utilization.[78] A Memorandum of Understanding released on February 2, 2000, indicates the prominent role played by the Secretaries of the State and Defense Departments in determining the conditions under which the U.S. should interrupt normal imaging operations to protect its national interests.[79]

In spite of these controls, there currently exist alternate sources for imagery data from a variety of foreign sources. Moreover, there is no guarantee that American remote-sensing providers will dominate the market. If used too often, shutter control is only likely to drive away customers who can easily access alternate sources.

To this day, due to the emphasis placed by the U.S. government on maintaining a thriving commercial satellite industry and possible constitutional challenges, shutter control has yet to be instituted. Instead, the government has opted to subsidize commercial firms with public funds, effectively becoming the proprietary owner of all imagery taken from a particular location. Such a situation occurred recently as part of Operation Enduring Freedom in Afghanistan. In this case, the Pentagon entered into a licensing agreement with Space Imaging to purchase all of its imagery being taken of Afghanistan using its highly advanced IKONOS satellite.[80] The agreement set the price of obtaining the imagery at a rate of $20 per square kilometer, costing the Pentagon $1.9 million per month.[81] Such action prompts the question whether such action represents sustainable government policy.

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[78] Gupta, Dr Vipin. *New Satellite Images for Sale: The Opportunities and Risks Ahead,* UCRL-ID 18140,CSTS-47-94. Livermore, Calif.: Lawrence Livermore National Laboratory, September 28, 1994.

[79] O'Connell et al., *"U.S. Commercial Remote Sensing Satellite Industry: An Analysis of Risks,"* March 6, 2002.

[80] Squeo and Regalado, *"Pinpoint Warfare,"* B1-B3.

[81] Bryan Bender, "Conflict brings debuts of information-heavy combat weapons," *The Boston Globe* (2001): A8.

Recent decisions by policymakers in Washington not to hinder the availability of commercial imagery pertaining to the war in Iraq suggest a possible shift in government policy and a recognition of the difficulty encountered when trying to prevent the dissemination of data. U.S. military capabilities may also be deemed so advanced that the inherent benefits of obtaining such imagery is offset entirely.

Any decision concerning the regulatory environment pertaining to commercial remote sensing satellite systems is complicated by the numerous stakeholders who possess legitimate interests in such a decision. The dual-purpose nature of these devices necessitates the consideration of all facets of those agencies involved. The resulting policy must therefore strike a balance between protecting U.S. national security concerns, foreign policy, and international obligations, promoting the development of the commercial remote sensing industry in the international marketplace, and finally, promoting the collection and dissemination of Earth remote sensing data for the public.[82]

B.) Licensing

Currently, NOAA is responsible for regulating the operations of American remote sensing satellite firms. This is achieved through its administering the licensing, monitoring their adherence to licensing obligations, and enforcing their compliance. On July 31, 2000, NOAA issued interim final regulations.[83] In contrast, the Department of State deals with the licensing of exports for remote sensing satellites, satellite components, and sensitive technologies. Due to their having potential military applications, these items are included on the U.S. Munitions List and subject to the Arms

[82] O'Connell et al., *"U.S. Commercial Remote Sensing Satellite Industry: An Analysis of Risks,"* March 6, 2002.
[83] 15 CFR Part 960.

Export Control Act.[84] Despite the fact that the Commerce Department (through NOAA) maintains the lead responsibility for licensing U.S. companies, other agencies have important roles in this process. These entities include the Department of Defense, the Department of the Interior, as well as the intelligence community.

C.) Congress

It is important to note that, despite not having a prominent role in the daily decision making apparatus pertaining to remote sensing satellite systems, Congress continues to play a significant role. Traditionally, the legislative branch has both continued to encourage the commercialization of land remote sensing and implemented restrictions. An example of such a limitation is the so-called Kyl-Bingaman Amendment that was attached to the FY 1997 National Defense Authorization Act. This provision prohibits private firms from receiving an American license to collect or disseminate imagery of Israel *"more detailed or precise than satellite imagery of Israel that is available from commercial sources."*[85] The proliferation of foreign companies in the commercial remote sensing industry may render this statute moot given the inability of the U.S. government to effectively regulate the dissemination of imagery obtained by international corporations and governmental entities.

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84 Id.
85 Id.

CHAPTER FOUR: THE EVOLUTION OF REMOTE SENSING SPACE LAW

In recent years, the commercialization of space has accelerated rapidly, a development which provokes numerous inquiries surrounding relevant international law. Some of the prominent issues in this area include national sovereignty, the dissemination of sensitive information and the regulation of dual-use technologies. Of specific interest is the legal status of remote sensing satellite systems. Questions arise at both the international as well as at the domestic level. Internationally one must ask what jurisdiction ought to be applied in regulating the industry. Domestically, questions surrounding the legal treatment of inventions for space, product liability and government aid persist. As remote sensing images proliferate on the open market, issues regarding the legality of such activities will remain.

I.) Definition

The United Nations defines remote sensing as *"a system of methods for identifying the nature and/or determining the condition of objects on the Earth's surface and of phenomenon on, below, or above it, by means of observation from airborne or spaceborne platforms."*[86] In a way, remote sensing is akin to reconnaissance. The two differ in the fact that satellites are able to peer into and see what is transpiring both on as well as beneath the surface of the Earth. The problem therefore lies in the dissemination of the data and the exact information obtained.

II.) Origins and Application

The methodology of remote sensing may be described as the perception of external objects. Initially, it was developed for application in air space by means of

[86] Bruce A. Hurwitz, The Legality of Space Militarization, New York: Elsevier Science Pubs., 1986, 252.

either aircraft or balloons. From a legal standpoint, such activity comes under the purview of air law with its legal implications concerning the sovereignty of the state situated below the imaging object. In other words, the sensed country maintains jurisdiction over such matters. Undertaking endeavors in the absence of the sensed state's permission would be illegal. However, when remote sensing transpires in the space far beyond that which it can feasibly control, as is the case with satellites, the sensed state is no longer able to assert its sovereignty.[87]

Part of the problem resides in the sheer breadth of remote sensing applications (See Table 10). As noted in previous chapters these include geology, geography, military, cartography, meteorology, agriculture, environmental science, forestry, oceanography, and hydrology. Remote sensing is used to track the spread of impervious surfaces, to monitor the impact on availability of ground water in urban areas, to monitor the mobility of both troops and equipment, to monitor nuclear nonproliferation efforts, as well as to determine the subterranean natural resources contained within the boundaries of a particular country. The majority of states continue to endorse an open skies policy based on the concept of free access strengthened by the concept of free information. In outer space, no claims of sovereignty may be exerted by states in the international system.[88]

Data concerns including the availability of information, access to it as well as the ability to use such data, matters of cost and licensing, and the requirement of expertise in order to maximize utilization of the information also prevail. Obtaining remote sensing images is merely one piece of the puzzle. Once possessed, these pictures must then be

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[87] Diederiks-Verschoor, I.H. Ph., Dr., An Introduction to Space Law, Boston, MA.: Kluwer Law International, 1999, 266.
[88] Id.

analyzed by a discernible and trained expert who can accurately indicate what is being depicted.

Additional legal issues pertaining to remote sensing satellite systems include the prohibition of national appropriation of outer space, the principle of equal rights for all states to freely use outer space, the freedom of scientific experimentation, the preservation of sovereign state rights over materials they launched, and the matter of state collaboration. No longer is state sovereignty limited in its vertical projection. Effective control by a state over space and their interests is impossible.[89]

III.) Space Law

Space law is the autonomous branch of international law which regulates relations between states to determine their rights and duties resulting from all activities directed towards outer space and within it and to do so in the interest of mankind as a whole.[90] Its subjects include both states and international organizations while the tenets of space law consist of treaties, customary international law, as well as general principles of international law.

Such a body of law differs markedly from air law which characterizes remote sensing when it is conducted by either airplanes or balloons. Air law is the set of both national and international rules concerning aircraft, air navigation, aerocommercial transport, and all relations public and private that arise from domestic and international air navigation.[91] Space law, in contrast, is legally not under the sovereignty of any state. The U.N. Committee on Peaceful Uses of Outer Space (UNCOPUOS) promulgates the majority of international law related to space activities, including remote sensing.

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89 Hurwitz, "The Legality of Space Militarization, 252.
90 Id.
91 Id.

Akin to air law which began with the first engine-powered flight undertaken by the Wright brothers in 1903, space law has undergone a similar evolutionary process that began on October 1, 1957 with the launch of Sputnik I by the former Soviet Union. It ought to be noted that the launch of Sputnik I was not accompanied by any widespread protest regarding the potential violation of another state's sovereignty over which the satellite would fly. This development was a pretense of future developments of space law.

Within a short period of time, what had once been an industry dominated by governments came to be characterized by the involvement of private companies. It quickly became apparent that legal rules pertaining to space were to become indispensable in order to provide guidelines for future conduct and avoid confusion and misaligned practices.[92] One thing was certain, government and private entities would continue to invest resources to explore space and develop technologies for a wide-range of potentially profitable and beneficial applications.

Existing standards that have evolved in space law are largely the result of U.S. efforts to render legitimate both military reconnaissance and civilian imaging from space. Between 1958 and 1967, international space law was defined loosely through the passage of numerous U.N. resolutions passed by the General Assembly.[93] Beginning in 1967, these principles were codified in treaties, the two most important of which are the 1967 Treaty on Principle Governing the Activities of States in the Exploration and Use of

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[92] Diederiks-Verschoor, I.H. Ph., Dr., An Introduction to Space Law, 266.
[93] E.g., resolution 1348 (XIII) of Dec. 13, 1958; 1472 (XIV) of Dec. 12, 1959; 1721 (XIV) of Dec. 20, 1961; 1802 (XVII) of Dec. 19, 1962; 1962 (XVII) and 1963 (XVIII) of Dec. 13, 1963; 2130 (XX) of Dec. 21, 1965; 2221 (XXI), 2222 (XXI), and 2223 (XXI) of Dec. 19, 1966; 1884 (XVIII) of Oct. 17, 1963; and 1962 (XVIII) of Dec. 13, 1963.

Outer Space Including the Moon and other Celestial Bodies[94] and Principles Relating to Remote Sensing of the Earth from Outer Space.[95]

A.) 1967 Treaty on Outer Space

The 1967 Treaty on Outer Space represents the cornerstone agreement upon which the majority of space law conventions are based. To date, the treaty has been ratified by ninety-one nations, including the United States. Article II of the Treaty outlines the principle of freedom of outer space, declaring *"outer space…is not subject to national appropriation by claim of sovereignty"* and *"shall be free for exploration and use by all states."*[96] It follows from this provision that states cannot exert control over any part of outer space in the same manner that is done in the airspace located immediately above national territories. Satellites are free to orbit the sovereign territory of another nation regardless of their being owned by a country other than the one being sensed.

In addition, the Treaty stipulates that the exploration and use of outer space are to be carried out for peaceful purposes in a manner that benefits all countries of the world. It requires that *"state parties to the treaty shall bear international responsibility for national activities in outer space…whether such activities are carried on by governmental agencies or by nongovernmental entities."*[97] This Treaty does not outlaw remote sensing, a manner seen to constitute tacit acceptance in accordance with existing tenets of international law.

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[94] Treaty on Principles Governing the Activities of States in the Exploration of Outer Space, Including the Moo and Other Celestial Bodies, United Nations, New York, January 27, 1967 (hereinafter *"1967 Treaty on Outer Space"*).
[95] *"Principles Relating to Remote Sensing of the Earth from Outer Space,"* United Nations General Assembly, New York, December 3, 1986.
[96] 1967 Treaty on Outer Space, art. II.
[97] Id., art. VI.

B.) Principles Relating to Remote Sensing of the Earth from Outer Space

The Principles Relating to Remote Sensing of the Earth from Outer Space were passed by the U.N. General Assembly on December 3, 1986. Much disagreement persisted prior to the adoption of these tenets primarily between the developed countries, led by the United States, and the developing nations, headed by the former Soviet Union. The U.S. held that collection and distribution of civilian remote sensing imagery should flourish without restriction. In contrast, the Soviets believed that the acquisition and dissemination of imagery should only be permitted with the consent of the sensed state.[98] It ought to be noted that the doctrines espoused by both parties directly reflected either the extent of progress or lack thereof made by their remote sensing systems. The principles represented a victory for the United States as Principle XII, rather than putting forth the right of prior consent, required 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."*[99]

Due to their lack of precision, the Principles have been interpreted largely in a manner which is most beneficial to the satellite operators themselves. Currently, Principle XII is believed to mean that a country is permitted to ask for a copy of a picture only if it is aware it is being imaged. Even then, the sensed country will not know which country or company requested the images and for what purposes.[100] Today, these Principles serve as the basis for the progressive development and codification of norms and operating rules of remote sensing.

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[98] Dehqanzada and Florini, *"Secrets for Sale: How Commercial Satellite Imagery Will Change the World"*.
[99] Principles, art. XII.
[100] Id.

IV.) Present-Day Status: Issues

Currently, remote sensing is divided into two primary segments: space and ground. The first piece, space, includes the collection, recording and transmission to Earth of the data collected by satellites. The second element of remote sensing, ground stations, include the reception, conversion, and data interpretation immediately followed by the distribution of the product to consumers. Remote sensing is therefore an operation that originates in the confines of space and includes a significant Earth-oriented end product.

It is important to note that, with respect to space law, all decisions taken must approved by the U.N.. This contrasts markedly with the voting method typically adopted by the U.N. General Assembly. Such a procedure demonstrates the level of international cooperation gained in the development of the law of outer space on both minor as well as significant points of contention.

A variety of legal and non-legal issues persist in the area of satellite remote sensing. These include the right of state sovereignty over natural resources. As remote sensing systems continue to advance in their capabilities, it is apparent that what can be seen today by operational remote sensing satellites includes elements situated below the surface, namely non-renewable natural resources. On the one hand, the inherent right for a country to pursue economic, social, and cultural development is embodied in Article 1, Paragraph 1 of the International Convention on Economic, Social and Cultural Rights.[101]

Inevitably, conflict is likely to arise between the principle of freedom of exploration and the usage of space as found in the 1967 Treaty on Outer Space and that state sovereignty over natural resources situated within a country's borders. However,

[101] International Covenant on Economic, Social and Cultural Rights, 1966, 993 U.N.T.S. 3.

the ability to detect such deposits is currently confined to a few advanced countries. One can imagine what may evolve when such profitable information is possessed by one country while the country in which the resources lie has no prior knowledge of the extent of its own territorial holdings? In such a case, who adjudicates? What legal principles are employed to resolve the matter? Clearly, this area of law has yet to fully mature.

As demonstrated by the programs involving weapons of mass destruction in Iran, Iraq and North Korea, it is becoming increasingly difficult for a country to hide its internal assets and activities. The capabilities of satellite imagery are likely to help rather than hinder global security as well as to supplement the efforts of the International Atomic Energy Association. As Ann Florini presciently states, the fundamental question that must be answered in order to devise an international legal regime for space law, *"Is satellite imagery a public or private good?"*[102] The answer to this question will go far to determine the formulation of tenets of international space law pertaining to remote sensing systems.

[102] Florini and Dehqanzada, *"Commercial Satellite Imagery Comes of Age,"* November 15, 2001.

<u>CHAPTER FIVE: A PROPOSAL FOR REGULATION</u>

I.) Overview of Existing Framework

In large measure, the current status of regulation and oversight pertaining to the remote sensing satellite industry is defined by both bilateral and *ad hoc* agreements between countries as well as between non-state entities. It is readily apparent, given the virtual hodgepodge of technological innovations and systems in operation, that a single overarching body that promulgates international standards pertaining to satellites in general and remote sensing satellites in particular is pertinent to ensure market stability and future growth.

A.) Current Regulatory Framework – U.S. Example

Presently in the United States, a wide range of federal agencies play an integral role in monitoring and regulating the remote sensing industry. These include the Bureaus of Export Administration and International Trade Administration within the Department of Commerce, the Office of Defense Trade Controls in the Department of State, the Office of Foreign Assets Control in the Treasury Department, the Federal Communications Commission, the Associate Administration for Commercial Space Transportation in the Federal Aviation Administration, and the Archives at the Department of Interior whose Geological Survey component maintains copies of all images taken by American satellites.[103] Taken together, U.S. remote sensing policy is thus highly fragmented. Jurisdiction is divided between a multitude of disparate entities.

[103] *"Proceeding for the Next Administration: A Discussion of Dual-Purpose Space Technologies."* (2000).

II.) A Model – ITSO (1964)

For the purposes of this study, an examination of the international regulatory framework that has evolved surrounding satellite communications is necessary. This structure provides a basis for further analysis and assessing the strengths and weaknesses of such a model.

Created in 1964, what is now known as the International Telecommunications Satellite Organization (ITSO) was originally referred to as Intelsat. Today, it is comprised of 148 member States. In its inception, the organization was devised as a cooperative among nations to provide the commercial space segment required for international public telecommunication services of the highest quality and reliability. ITSO was planned to ensure access from any point around the world to such technological innovations. Since that time, the organization has evolved to its current status of supervising the public service of the private and commercial telecommunications entity, Intelsat.[104]

Headquartered in Washington, D.C., ITSO was conceived through the promulgation of the Communications Satellite Act signed by President Kennedy in 1962. Today, it stands as a multinational intergovernmental treaty organization incorporating the principle set forth in U.N. General Assembly Resolution 1721 (XVI) which establishes that satellite communications ought to be made available to all nations on a non-discriminatory basis. Consistent with this measure, ITSO produces a report each year describing the activities undertaken by the Organization that is then transmitted to the U.N. Secretary General.

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[104] http://www.itso.int/members.htm (*Accessed on* April 20, 2003).

Recently ITSO was restructured. Its satellites and orbital filings were transferred to Intelsat. This shifted ITSO from a treaty-based organization that possessed a monopoly position in providing international satellite services, to one that ensures international satellite public services. The member States tasked ITSO with supervising and monitoring the public service obligations of Intelsat. The current structure of ITSO consists of an Assembly of Parties, comprised of all member states, an Executive Organ headed by the Director General, and a Panel of Legal Experts that helps resolve disputes in connection with the treaty Agreement.

III.) French Proposal – ISMA (1978)

The initiative to create an overarching organization for the remote sensing satellite industry is not a novel idea. In fact, during the first session of the U.N. Disarmament Conference in 1978, France formally proposed the creation of a specialized U.N. agency which it referred to as the International Satellite Monitoring Agency (ISMA).[105] The impetus for this proposal was primarily military. France was eager to ensure international access to satellite imagery while helping to strengthen its own confidence and security during the disarmament process. The proposal set up a satellite monitoring agency, one envisaged to become an adjunct to disarmament agreements and to increase confidence in the international community *"by providing interested parties with information that they were entitled to demand."*[106] Among the elements addressed in the plan were the acquisition, processing, and dissemination of data and information.

The text of the measure was divided into Guiding Principles, Functions, Statute, Technical Resources, Financing, and Settlement of Disputes. ISMA's responsibilities

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[105] Diederiks-Verschoor, I.H. Ph., Dr., An Introduction to Space Law, 266.
[106] Memorandum from the French Government Concerning an International Monitoring Agency, February 24, 1978, Preamble, par. 8.

were to collect, process and disseminate information obtained by means of Earth observation satellites while respecting state sovereignty. No details were provided to indicate how this was to be accomplished. Functionally, ISMA would participate in the investigation of situations as they arose and monitor the implementation of international disarmament and security agreements.

In addition to the structure of ISMA, France indicated that it foresaw a future expansion of the organization in accordance with technological advancements. This would be conducted in three stages – a data processing center supplied by states possessing observation satellites, data-receiving stations directly linked to those states with satellite capabilities, and the observation satellites themselves needed to perform the aforementioned tasks.[107] The proposal was quickly discarded by the international community. Following the end of the Cold War and the proliferation of asymmetrical threats including terrorism and weapons of mass destruction, the value of such an entity has reemerged.

V.) Proposal - IRSA

A.) Analysis, Measures of Cost and Effectiveness, and Recommendation

Acknowledging the current fragmented state of international regulation over the remote sensing satellite industry, confined primarily to the purview of the COPUOS, it is imperative for an organization to be constructed which will ensure the presence of a stable regulatory regime and industry. Current uncertainties dominate the marketplace and lead to an unrealized potential of the commercial sector. This combines with a lack of shared information to increases suspicions, further harming the future of the remote

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[107] Id.

sensing industry. It is therefore recommended that the International Remote Sensing Agency (IRSA) be created within the confines of the United Nations, possibly housed within a larger overarching body which would be given jurisdiction over the satellite industry in its entirety.

Akin to both the IAEA and the World Meteorological Organization (WMO), IRSA would be entrusted with numerous tasks. It would play a coordinating role in gathering, processing and analyzing information. In addition, IRSA would monitor international remote sensing launches, systems, technologies, and organizations. Perhaps most importantly, the Agency would serve as a one-stop-shop whereby those interested in gaining access to remote sensing information could inquire. Such an entity would streamline the numerous programs and projects currently in operation throughout the world, leading to a reduction in overall costs and a marked improvement in the effectiveness, efficiency and degree of international cooperation embedded in these activities.[108]

Moreover, IRSA would be entrusted with the task of realizing the formalization of the United Nations Principles put forth in 1986. Its charter would draw upon the 1978 French proposal, utilizing it as a framework to move beyond addressing the sole issue of disarmament in order to enable widespread access to remote sensing applications without sacrificing the security interests of its member States. Embedded within IRSA would be a marked degree of flexibility, allowing the organization and its administrators to respond to new technologies, unforeseen developments in the marketplace, as well as emerging threats.

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[108] Andem, International Legal Problems in the Peaceful Exploration and Use of Outer Space, 511.

The structure of IRSA would adopt aspects of both that which characterize ITSO as well as the Committee on Earth Observation Satellites (CEOS) created at the G-7 Summit in 1984 to serve as the *"focal point for international coordination of space-related, Earth observation activities"*.[109] Since the U.N. Principles were promulgated, CEOS has served as the focal point for the formulation of remote sensing policy in the international community. An Assembly of Parties, comprised of all member states, would be the primary decision making body with guidance and oversight provided. An Executive Organ headed by a Director General would provide guidance and maintain oversight of the body's daily activities. Lastly, a Panel of Legal Experts would meet periodically to help resolve disputes brought in connection with the Treaty Agreement.

Indeed, the preceding paragraphs are presented merely as a guidepost for future action. Prior to substantive discussions being held, the international community must realize the mutual benefits inherent in entering into such an agreement. The remote sensing satellite industry will continue to be a leading player, one that continues to push the envelope of transparency and in which each country maintains a vested interest. Yet, it remains to be seen whether policy makers can reach a general consensus on the potential good that would come result from the establishment of IRSA.

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[109] Michael R. Hoversten, *"United States Regulation of Remote Sensing from Outer Space Including National Security Concerns,"* (2000):

CHAPTER SIX: MARKETPLACE

Within the next few years, in excess of 1,000 commercial satellites, representing over thirty-five systems and networks from a variety of countries are projected to be in orbit.[110] These systems will perform a wide range of intelligence, surveillance, and reconnaissance tasks. A recent estimate conducted by the Teal Group indicates that over 1,100 satellites valued at approximately $40 billion will be launched between now and 2005.[111] Over 200 of these will be geostationary satellites and over 900 will be low Earth orbiting satellites. The capabilities of these systems are diverse, dictated by the market interests of their owners. The implications of such technology are only beginning to be felt in both domestic and international policy arenas.

By the end of this year, it is estimated that eleven private companies from a total of five different countries will have launched high-resolution commercial remote sensing satellites into orbit.[112] However, due to a variety of factors, the state of the current market remains largely uncertain (See Figure D). Products are continuously thrust into a highly unpredictable marketplace. In addition, American companies are forced to compete against heavily subsidized foreign competitors. Regulatory problems abound as countries attempt to reach a precarious balance between commercial success and national security concerns. Finally, many commercial companies are having to compete against highly developed and oftentimes less costly aerial remote sensing technologies.

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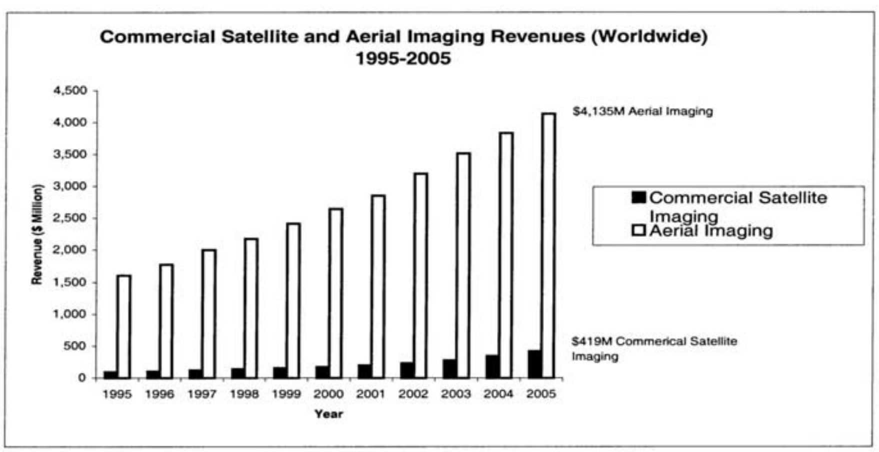
[110] *"Military Dependence on Commercial Satellite Communications Systems – Strength or Vulnerability?"* in Air War College. November 11, 2001. Available at http://research.au.af.mil/papers/student/ay1999/awc/99-128.pdf.; Pericles Gasparini Alves, Evolving Trends in the Dual-Use of Satellites. (1996).

[111] http://www.tealgroup.com (*Accessed on April 27, 2003*).

[112] Dehqanzada and Florini, *"Secrets for Sale: How Commercial Satellite Imagery Will Change the World"*.

The U.S. government continues to maintain its role as an integral patron of the commercial remote sensing satellite industry. Federal agencies have entered into numerous public-private partnerships that support the development of imaging systems. Examples of such collaboration include NASA funding for OrbImage's OrbView-2 imaging satellite as well as DOD funding for several hyperspectral imaging sensors currently under development. The Commercial Imagery Strategy presented to Congress in April 1999 by NIMA and the NRO outlines the government's ongoing working relationships with the three leading U.S. commercial imaging satellite firms and assistance provided to their ground infrastructures.[113] Its objective has been to permit such imagery being delivered to government users within 24 hours of their being received by the ground stations.

FIGURE D: REVENUES[114]



By 2005, it is estimated that the satellite imagery market will have grown over 202% from present day levels, rising to an estimated $420 million dollar industry.[115]

113 Squeo and Regalado, *"Pinpoint Warfare,"* B1-B3.
114 Frost & Sullivan, World Remote-Sensing Data and GIS Software Markets, 1999.
115 Florini and Dehqanzada, *"Commercial Satellite Imagery Comes of Age,"* November 15, 2001.

Over the next five years, twenty-five additional satellites, each possessing at or better than 1-meter resolution are expected to be launched into orbit by nine different governments and companies in two nations.[116] This expansion is quite remarkable considering the formidable startup costs encountered (See Table 8).

According to estimates made by both Space Publications and the consulting firm A.T. Kearney, worldwide revenues from space are currently $88 billion annually and are projected to reach over $125 billion this year.[117] What is surprising about this development is that the government is not the driving force behind this change. Rather, the increase in revenues is being fueled by the commercial sector, one that is enjoying an annual growth rate of 20% compared to only 2% in the government. In 1996, revenues gained by the commercial sector surpassed those of the government for the first time.[118] In fact, commercial revenues are expected to account for nearly 70% of total space-based revenues overall in 2003.[119] Together, these figures exemplify the marked shift in the remote sensing industry from government-sponsored systems to those highly advanced devices proliferating in the private sector.

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116 *"History and Development of Satellite Remote Sensing,"* in University of Delaware. August 2001. Available at http://www.udel.edu/Geography/DeLiberty/Geog474/geog474_history.html.
117 Moorman, General Thomas S., Jr.., *"The Explosion of Commercial Space and the Implications for National Security."* (1998).
118 Smith, *"A Double-Edged Sword: Controlling the Proliferation of Dual-Use Satellite Systems,"* 31-68.
119 Moorman, General Thomas S., Jr.., *"The Explosion of Commercial Space and the Implications for National Security."*

<u>CHAPTER SEVEN: CHALLENGES</u>

I.) Diplomatic

As the military strategist Carl von Clausewitz observed in his seminal work *On War*, the military act of war is inextricably linked to the political and diplomatic processes of a state which, taken together, forms a continuum.[120] In order to assess the impact of commercial satellite imagery on national security policy, one must first review how this may affect diplomacy, the so-called *"art of the state"*.[121]

These new systemic interactions across traditional boundaries will affect the conduct of foreign affairs. No longer is diplomacy limited to foreign ministries and diplomats. The public, non-governmental organizations, companies, and individuals all possess the ability to profoundly alter international affairs and to focus attention on such important global problems confronting a post-Cold War world as humanitarian disasters, environmental problems, and disarmament verification.

Although economic strength, military power, and relations between governments remain essential elements for maintaining global leadership and stability, the increasing degree of growing interdependence and interaction is forcing governments to reevaluate the way in which they address issues that cannot be defined by traditional borders. Transnational threats such as terrorism, environmental degradation, international crime, disease, and financial instability pose unique challenges. As Barry Fulton of the Center for Strategic and International Studies wrote, "*Effective leadership in the United States in sustaining international stability depends upon the ability of our foreign affairs agencies*

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120 Peter Paret, <u>On War</u>. (1989): 752.
121 <u>Id</u>.

to change and adapt to the imperatives of the information age. Without change, diplomacy is threatened with irrelevance".[122]

As the role of information in statecraft and warfare grows, information technologies are creating greater transparency in political and military affairs. In other words, there are fewer and fewer secrets that can be kept as information about the composition of a government or a military entity are made readily available to consumers. In addition, the compression of time increases the pressures exerted on decision makers who must identify which information is relevant and respond almost immediately to both a government and a public that has access to the same information. Such a reality places an increased premium on public diplomacy in international affairs and on timing, maneuvering and stealth in military operations. This shift, a direct result of the creation of an open skies effect, contains both positive and negative aspects. On the one hand, access to information provides countries with their own early warning capability on potential problems, allowing sufficient preparation time to formulate a response. In contrast, governments fear that this very openness will present a threat to their norms and cultures as well as become a potentially influential means of American influence.

The proliferation of technology is here to stay. The momentum is so great that one will find it impossible to put the genie back in the bottle. As the early days of commercial satellite imagery demonstrated, transparency holds a diversity of challenges ranging from poor quality interpretation, superficial or biased analysis and denial and

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[122] Jonathan Spalter and Kevin Moran, "Toward a New Digital Diplomacy: Information Technology and U.S. Foreign Policy in the 21st Century*," Information Impacts Magazine,* May 1999,

deception.[123] These tendencies lead to an increase in states' vulnerability to external pressure. The incident involving a downed Navy EP-3 reconnaissance plane over China is but one example of the increasing availability of imagery data. However, even though the plane's location is available for the entire world to see, its mission – the gathering of and analysis of information – paradoxically remains as important as ever. The part played by intelligence and diplomacy are not diminished but rather their roles are changed.

As the policy making process compresses the decision time available due to the proliferation of technology, new challenges arise. These developments, including the dramatic impact of media outlets on such political decisions as humanitarian intervention and peace operations, have complicated foreign policy. The so-called *"CNN-effect"* [124] has led to the growing importance of having a proactive public diplomacy. George Shultz, former Secretary of State, recounts how the State Department's traditional cable message system was overtaken by a new communication technology employed during a Lebanon crisis involving both Israel and the Palestinian Liberation Organization. He noted that:

> *I became aware of an acute problem with the State Department system of crisis management: the pace of events had outstripped the traditional methods of receiving cable messages from overseas and responding with written instructions to our posts. There simply was not the time to draft, type, code, transmit, decode, process, and read written telegraphic traffic. This was the first diplomatic crisis handled by instant voice communications via satellite.*[125]

The dual-use nature of satellite information technology poses significant security concerns for governments. This has led to an increased degree of cooperation and interaction between states, each of which are hoping to curb the dissemination of

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[123] Kevin M. O'Connell et al., "U.S. Commercial Remote Sensing Satellite Industry: An Analysis of Risks," *RAND* (2001).
[124] http://www.ksg.harvard.edu/presspol/publivcations/pdfs/70916_R-18.pdf (*Accessed on* April 25, 2003).
[125] Power and Conflict in the Age of Transparency, 239.

sensitive technologies to potentially hostile entities. In addition, it has brought forth ambiguity concerning the type and degree of threats that such countries as the United States are facing.

Following the events of September 11, 2001, this discussion is likely to continue. Information will remain an indispensable resource in the New World Order – aiding democratic institutions, preventing their reversion to authoritarianism, preempting and resolving regional conflicts, and addressing threats of terrorism, crime, and proliferation. Commercial satellite capabilities will be integral to gathering, analyzing and disseminating information for both state and non-state actors alike.

II.) Data Interpretation

The old adage which states that a picture is worth a thousand words is oftentimes true but the principle is devoid of value if it is not viewed in the proper context. Obtaining information that is actionable from satellite imagery requires a significant degree of expertise and experience. Analysts must be aware of the site being viewed before gauging what the image depicts. As high-resolution remote sensing satellites proliferate in the commercial sector, their utility will depend on their ability to fulfill the needs of consumers. In other words, both data acquisition and interpretation are rendered just as important than the satellites themselves.

Collecting imagery requires exact coordinates. In fact, even if such information is obtained, one may still encounter difficulties if the object is mobile or if it is being camouflaged using well-established techniques of deception. Satellites are not able to immediately snap a picture of the right place at the right time. Existing commercial devices require anywhere from between 1 to 24 days to obtain an image.[126] The price of images, if bought in bulk, can be as low as $7 per image.[127] In addition, customers can currently pay an additional $3,000 to obtain new pictures rather than receive an older, archived photo. At present, obtaining a new photo takes anywhere between 7 and 59 days, significantly lessening U.S. concerns over the immediate availability of precise imagery of sensitive locations.[128] Continuous global coverage of the Earth is slow to materialize. Until this comes to fruition, access to timely satellite imagery will remain hindered.

Impediments to the utility of satellite imagery are compounded further by technical limitations, including the conditions under which the devices are forced to operate. Despite the advent of extremely accurate 1-meter resolution, one is not able to depict such vital information as weapons systems, onboard cargo and key features of specific objects. In the event that the correct image is obtained under the right conditions, photo analysts must understand weather conditions, surface features, seasonal changes, shadows, surroundings, and differing shapes and sizes.[129] Moreover, personnel require a great deal of prior knowledge about what the object being examined looks like from space. Gaining the requisite expertise in this area therefore requires years of training. In the federal government sector, analysts undergo a full sixteen weeks of basic training and work one-and-a-half years before reaching the level of apprentice. Even

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[126] Dehqanzada and Florini, *"Secrets for Sale: How Commercial Satellite Imagery Will Change the World"*.
[127] Squeo and Regalado, *"Pinpoint Warfare,"* B1-B3.
[128] Id.
[129] Dehqanzada and Florini, *"Secrets for Sale: How Commercial Satellite Imagery Will Change the World"*.

then, there remains a 90% rate of error among government imagery analysts during their first three years on the job.[130]

III.) Military

> *...when masses of troops are employed, certainly they are widely separated, and ears are not able to hear acutely nor eyes to see clearly. Therefore officers and men are ordered to advance or retreat by observing the flags and banners and to move or stop by signals of bells and drums.*[131]
>
> - Sun Tzu, Art of War

The above quote, taken from the renowned war theorist Sun Tzu's seminal work *The Art of War*, applies as much today as it did when it was written in 500 BC. Both eras found effective and instantaneous communication capabilities essential in order to succeed in international affairs. The proliferation of information has had dramatic and far-reaching effects on the conduct of military affairs. These include the widespread diffusion of knowledge, the importance of timeliness of data, as well as a contraction in the amount of time available to make key decisions. In a world where the sources of economic, political and military power are becoming more diffuse and the United States stands as the world's only superpower in a newly multi-polar world, the shaping of space policy has been permanently changed and is becoming more important as a way to project force quickly and efficiently.

Today, although the first military communications satellite was launched over twenty-five years ago, *"roughly 60% of the United States military's satellite communications is done over commercial satellites"* as stated by Major Perry Nouis of

[130] Statement made by Dr. Steven Livingston during the *"No More Secrets? Policy Implications of Commercial Remote Sensing Satellites"* conference at the Carnegies Endowment for International Peace, May 26, 1999.
[131] Jones, Duane A., Colonel, USAF., *"Increased Military Reliance on Commercial Communications Satellites: Implications for the War Planner."*

the United States Space Command.[132] Joint Vision 2010, which provides the conceptual template for how the United States defense establishment will leverage technological opportunities to achieve new levels of effectiveness in joint war fighting, depicts a military with unprecedented mobility, precision and dispersion of force abroad. These capabilities make it inherent that satellites are and will continue to remain integral components to military operations.

Modern employment of United States armed forces in such conflicts as the Persian Gulf War, Kosovo, Afghanistan, and now Iraq have necessitated an unprecedented demand for information derived from commercial satellite systems. These trends are overtly evident in the current military campaign in Iraq where approximately 68% of the bombs deployed possessed satellite-driven precision guidance systems.[133] Moreover, much like airspace, communications are becoming increasingly crowded. In the 1991 Gulf War, networked computers fed information at a rate of 192,000 words per minute. In the near future, the military expects to be transmitting 1.5 trillion words, the equivalent of the entire Library of Congress, each and every minute.[134]

For the military, information obtained from satellites can improve one's situational awareness. During the Persian Gulf War, often called the world's first space war, the United States military became a significant customer of commercial satellite imagery procured by such devices as the French SPOT satellite to help meet the growing demand for information. Examples of the utility of the data obtained by these technologies are widespread and were most recently illustrated by the Pentagon's

[132] "Military Satellite Communications: The March Toward Commercialization." in *Defense Daily*. November 15, 2001. *Available at* http://www.defensedaily.com/reports/satcom_4.htm.
[133] Matthew Brzezinski, "The Unmanned Army," *The New York Times* (2003).
[134] Id.

willingness to embed reporters in the field alongside troops in Iraq. Operation Iraqi Freedom demonstrated the critical service provided by updated mapping and imagery delivered by commercial satellites to the troops in the field. This is due to the fact that the Pentagon today commands more and better reconnaissance satellites than all the rest of the world combined. American forces have begun using space-relayed data in a significant way. Space assets were likely critical to the lightning conquest of Iraq. The American lead in this is only expected to increase given the fact that the Air Force now has the second-largest space budget in the world, after NASA's.[135]

In his work *To End a War*, former Ambassador Richard Holbrooke depicts a type of digital diplomacy that evolved during the conflict in Kosovo in the 1990s.[136] The book focuses on one particular incident which he terms the *"Clark Corridor*" in which, during the Dayton peace negotiations, a special unit of the Defense Mapping Agency was employed to help facilitate a dialogue in an effort to resolve a territorial dispute between the Serbians and the Bosnians. Among the items this unit brought with them was a highly classified imaging system called PowerScene. Costing nearly $400,000, this device was first used during Desert Storm. In Dayton, the machine was employed to integrate military film from Bosnia to provide a type of virtual reality machine, visible in three dimensions, and accurate down to two yards. The viewer could fly from a variety of vantage points using a joystick.

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[135] Easterbrook, Gregg. "American Power Moves Beyond the Mere Super." *The New York Times*. New York: The New York Times Company, April 27, 2003. *Available at* http://www.nytimes.com/2003/04/27/weekinreview/27EAST.html?pagewanted=all&position=.
[136] Richard C. Holbrooke. To End a War. New York: Random House, 1998, 283-287.

As Holbrooke notes, *"To foreigners especially, it was a vivid reminder of America's technological prowess"*.[137] This video game of sorts solved one of the primary areas of dispute, the area of Gorazde, in which the device allowed the policymakers to visualize and agree upon a corridor through the mountainous terrain to link the two cities of Sarajevo and Gorazde. Events such as this have prompted many to classify the development of satellite technology as a Revolution in Military Affairs (RMA). However, although RMAs are often prompted by technological innovations, it is the ability to tie these capabilities together and the effect of this technology that leads one to apply such a classification.

[137] Id.

CONCLUSION

In 1996, commercial spending on satellites eclipsed military spending for the first time, a cross-over year. By May 1998 there were more commercial satellites operating in orbit than those owned by the military.[138] Currently, over thirty-five nations and seven international companies or consortia are involved in space.[139] This information represents two indications that the civilian-military affairs paradigm is in the midst of a profound transition. Such a shift towards an increased dependency on commercial space assets is forcing politicians and policymakers alike to reassess the delicate balance between the commercial industry, one focused on profit and progress, and the military applications of the technology, critical to national security.

A dramatic increase in access to powerful personal computers, lower cost telecommunications, global media coverage, internet, commercial observation satellites, and global positioning satellites are all contributing to a marked increase in international transparency. The resulting condition is one that both enhances and complicates the ability of a state to manage conflict. On one side, a heightened degree of transparency provides policymakers with new instruments for supporting conflict prevention, management and resolution. At the same time however, national governments no longer serve as the sole proprietors of information. This development threatens to diminish the preeminent role of states in international relations and correspondingly increases the importance placed on non-state actors.

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[138] Florini and Dehqanzada, *"Commercial Satellite Imagery Comes of Age,"* November 15, 2001.
[139] Miller, Dennis M., Lt. Colonel, USAF and Stocker, John, E., III, Lt. Colonel, USAF., *"Commercialization of Space Systems: Policy Implications for the United States."*

Due in large part to their global coverage, satellite information technologies are becoming the drivers of expanding transparency, promoting the flow of copious amounts of data. The advent of new satellite technologies are allowing both governments and non-state actors to observe and locate major developments that occur anywhere in the world and then transmit that data for immediate consumption and analysis to the global network. An important implication of these trends is that the proliferation of commercial satellite communications systems transfers much of the control states have exerted over these technologies in the past to entities such as news organizations or businesses.

In the twenty-first century, any organization in possession of sufficient resources will possess the capability of deploying satellites to monitor the actions of others and to utilize a global communication network that passes the information from one location to another instantaneously. The effects of this are not yet fully known. After the attack on the World Trade Center, images taken by IKONOS 2, the first commercial high-resolution satellite, were broadcast worldwide. Owned by the American company Space Imaging, IKONOS demonstrated the advanced capabilities of commercial remote sensing satellites and illustrated their inherent value to a wide range of customers including policymakers, first responder emergency personnel, military, and commercial businesses.

The war in Iraq demonstrated the increasing strength possessed by the U.S. military and its reliance on information and precision-guided weaponry. Pictures broadcast into the homes of millions of Americans depicted intricately laid graphic maps of Baghdad made possible due to commercial satellite companies. These images permitted a virtual flyover by the viewer onto the battlefield before even a single shot was fired. In fact, prior to the outbreak of hostilities, the U.S. government further cemented its ties with the commercial industry by establishing high-speed lines between NIMA and both Space Imaging and Digital Globe, thereby decreasing the likelihood of any information disruption. [140] This further illustrates the premium placed on obtaining such data in a timely fashion.

On June 7, 2002, George Tenet, Director of the Central Intelligence Agency (CIA), issued a memorandum ordering the U.S. intelligence community to utilize domestic commercial space imagery to the greatest extent possible and to turn over all its mapping requirements to commercial companies. In doing so, not only did this implicitly acknowledge the capabilities of the commercial remote sensing sector but, given the fact that these images were already publicly available, it enabled the widespread sharing of information with coalition partners.

Irrespective of the indicated rise in the profitability of the commercial remote sensing sector, it remains true that the U.S. government serves as the industries largest customer. Recently, on January 16, 2003, the Pentagon announced its intention to purchase up to $1 billion worth of high-resolution satellite imagery over the next three years from Space Imaging and DigitalGlobe, its largest such agreement in history. Under the so-called Clearview contracts, NIMA will buy a minimum of $120 million worth of imagery from Space Imaging and $96 million worth of data from DigitalGlobe.[141] Both of the contracts have a maximum value of $500 million and mark the strongest commitment yet by the U.S. government to buy products and services from the U.S. commercial satellite imaging industry.[142]

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[140] Squeo and Regalado, *"Pinpoint Warfare,"* B1-B3.
[141] Id.
[142] Id.

As the government contemplates future endeavors in the area of remote sensing, including its next generation program currently entitled Future Imagery Architecture, it is becoming increasingly relevant to discuss the viability of an international regulatory agency such as the proposed International Remote Sensing Agency.[143] Governments and private entities alike are faced with an uncertain climate, one in which it is becoming increasingly difficult to balance national security concerns, accessibility to pertinent information on the commercial market and uniform international rules and regulations. If this increasingly global industry is to succeed, the international community must begin to contemplate its structure. Without safeguards on the proliferation of commercializing space, the next step is likely to result in its further militarization.

In response to the question proposed at the outset of this analysis, Dr. Florini states the following,

> *"...satellite imagery cannot unlock every secret. While the new high-resolution remote sensing systems will be able to detect large-scale troop movements, mass graves, and deforestation, they will not be able to reveal the intentions of those troops or who is buried in the mass graves, or how the deforestation can be reversed. In virtually all cases, other sources of information will be necessary to unmask what cannot be observed from space."*[144]

Although remote sensing satellites lift the veil of secrecy imposed by the limitations of distance, lack of access and rudimentary technology, they fall short of establishing an environment in which human intelligence is no longer of value. Establishing the International Remote Sensing Agency would provide the foundation upon which future global activities in the satellite imagery industry could evolve and augment mankind's own capabilities in a regulated environment.

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143 Loeb, *"Spy satellite program faces hardship, US says,"* A2.
144 Dehqanzada and Florini, *"Secrets for Sale: How Commercial Satellite Imagery Will Change the World"*; "Space Almanac 2001," *Air Force Magazine on the Web* (2001).

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TABLE 2

Ground Resolution Requirements For Militarily Significant Targets (in meters):

Target	Detection	General ID	Precise ID	Description	Technical Analysis
Vehicles	1.5	0.6	0.3	0.06	0.045
Radio	3	1	0.3	0.15	0.015
Radar	3	1.5	0.3	0.15	0.015
Command and Control	3	1.5	1	0.15	0.09
Missile Sites	3	1.5	0.6	0.3	0.045
Aircraft	4.5	1.5	1	0.15	0.09
Rockets and Artillery	1	0.6	0.15	0.05	0.045
Airfield Facilities	6	4.5	3	0.3	0.15
Bridges	6	4.5	1.5	1	0.3
Troop Units	6	2	1.2	0.3	0.15
Supply Dumps	1.5-3	0.6	0.3	0.03	0.03
Roads	6-9	6	1.8	0.6	0.4
Minefields	3-9	6	1	0.03	0.09
Submarines	7.5-30	4.5-6	1.5	1	0.03
Surface Ships	7.5-1.5	4.5	0.6	0.3	0.045
Coasts, Beaches	15-30	4.5	3	1.5	0.15
Railroad Yards	15-30	15	6	1.5	0.4
Ports, Harbors	30	15	6	3	0.3
Urban Areas	60	30	3	3	0.75
Terrain Features	-	90	4.5	1.5	0.75

Source: Vipin Gupta, "New Satellite Images for Sale: The Opportunities and Risks Ahead," Center for Security and Technology Studies, Lawrence Livermore National Laboratory, (University of California, 1994), p. 2; Anne Florini, "The Opening Skies: Third Party Imaging and US Security," *International Security*, Vol. 13, No. 2 (Fall 1988), p. 100.

TABLE 3

Payloads in Orbit:

Launcher/Operator	Objects	Launcher/Operator	Objects
Russia	1,371	Mexico	6
United States	980	Spain	6
Japan	71	Argentina	5
ITSO*	56	Czechoslovakia	4
France	50	Thailand	4
China	35	International Space Station	3
ESA	30	Israel	3
United Kingdom	29	Malaysia	3
Germany	20	Norway	3
India	20	Turkey	3
Canada	17	Egypt	2
Italy	11	France/Germany	2
Luxembourg	11	Philippines	2
Brazil	10	Chile	1
Indonesia	9	Denmark	1
Saudi Arabia	9	Portugal	1
Sweden	9	Singapore	1
NATO	8	South Africa	1
Australia	7	Taiwan	1
South Korea	7	United Arab Emirates	1
		Total	2,813

Source: http://www.msua.org/satellite_101.htm.

TABLE 4

U.S. Satellites in Orbit (as of 12/31/2000):

Launch Year	Military	NASA & Civilian	Commercial	Total
1958-64	31	42	2	75
1965	18	18	0	36
1966	15	20	0	35
1967	27	16	0	43
1968	13	13	0	26
1969	15	12	0	27
1970	10	4	0	14
1971	12	3	0	15
1972-73	16	12	1	29
1974	4	4	2	10
1975	5	6	2	13
1976	10	6	6	22
1977	11	4	0	15
1978	14	7	2	23
1979-80	18	2	3	23
1981	5	3	3	11
1982	5	0	6	11
1983	14	4	4	22
1984	15	3	5	23
1985-86	15	2	6	23
1987	10	1	0	11
1988	10	2	4	16
1989	14	3	0	17
1990	22	3	4	29
1991	10	4	2	16
1992	11	4	4	19
1993	13	5	3	21
1994	11	4	5	20
1995	10	4	10	24
1996	15	5	6	26
1997	9	5	65	79
1998	7	7	71	85
1999	8	11	57	76
2000	8	19	18	45
Total	435	254	291	980

Source: http://www.msua.org/satellite_101.htm.

TABLE 5

<u>U.S. Space Funding</u> (as of 9/30/2000):

FY	NASA	DoD	Other	Total
1969	3,822	2,013	170	6,005
1970	3,547	1,678	141	5,366
1971	3,101	1,512	162	4,775
1972	3,071	1,407	133	4,611
1973	3,093	1,623	147	4,863
1974	2,759	1,766	158	4,683
1975	2,915	1,892	158	4,965
1976	4,074	2,443	199	6,716
1977	3,440	2,412	194	6,046
1978	3,623	2,738	226	6,587
1979	4,030	3,036	248	7,314
1980	4,680	3,848	231	8,759
1981	4,992	4,828	234	10,054
1982	5,528	6,679	313	12,520
1983	6,328	9,019	327	15,674
1984	6,858	10,195	395	17,448
1985	6,925	12,768	584	20,277
1986	7,165	14,126	477	21,768
1987	9,809	16,287	466	26,562
1988	8,322	17,679	741	26,742
1989	10,097	17,906	565	28,568
1990	11,460	15,616	511	27,587
1991	13,046	14,181	777	28,004
1992	13,199	15,023	805	29,027
1993	13,064	14,106	739	27,909
1994	13,022	13,166	640	26,828
1995	12,543	10,644	766	23,953
1996	12,569	11,514	834	24,917
1997	12,457	11,727	795	24,979
1998	12,321	12,359	829	25,509
1999	12,459	13,203	979	26,641
2000	12,521	13,197	991	26,709
Total	$278,391	$293,752	$16,607	$588,750

Source: http://www.msua.org/satellite_101.htm.

TABLE 6

<u>Commercial Satellite Systems in the U.S. (1984-1999)</u>:

Company	**Date Applied**	**Date Approved**	**System**
WorldView Inc./EarthWatch	15-Jul-92	4-Jan-93	EarlyBird
EOSAT	6-Oct-92	17-Jun-93	Landsat 6
Lockheed/Space Imaging	10-Jun-93	23-Apr-94	IKONOS
OrbImage	14-Dec-93	5-May-94	Orbview-1
OrbImage	14-Dec-93	1-Jul-94	Orbview-2
Astrovision	26-Mar-94	25-Jan-95	N/A
EarthWatch/Ball	18-May-94	2-Sep-04	QuickBird
GDE Systems Imaging/Marconi N.A.	2-Mar-95	14-Jul-95	N/A
Motorola	31-Mar-95	1-Aug-95	N/A
Boeing Commercial Space	19-Jan-96	16-May-96	N/A
CTA Corporation	6-Sep-96	9-Jan-97	N/A
RDL Space Corporation	1-Mar-97	16-Jun-98	RADAR-1
Space Technology Development Corporation	11-May-98	26-Mar-99	NEMO

Source: National Oceanic and Atmospheric Administration; National Environmental Satellite, Data, and Information Services, May 13, 1999.

TABLE 7

Space Imagery Revenues (millions):

	Actual				Projected		
	1996	1997	1998	1999	2000	2001	2002
U.S.	28	32	38	43	50	63	83
Rest of World	74	88	101	111	123	134	148
Total	102	120	139	154	173	197	231
Market Share (%)							
U.S. Share	27.5	26.7	27.3	27.9	28.9	32	35.9
U.S. Annual Growth		14.3	18.8	13.2	16.3	26	31.7
Total Annual Growth		18.9	14.8	9.9	10.8	8.9	10.4

Source: Futron, Inc. (2001).

TABLE 8

Estimated Costs of Entering Market for High-Resolution Satellite Imagery:

Component		Estimated Cost (millions)
Satellite Sensor and Spacecraft		45-300
Ground Segment		33-65
A.) Primary Ground Station		20-35
B.) Backup Ground Station		10-15
C.) Remote Tracking Sites		3-5 each
Launch		12-60
Vehicle Type	*Payload (kg.)	
Ariane 42P (French)	6,100	65-85
Long March 2C (Chinese)	3,200	20-25
PSLV (Indian)	2,900	15-25
Athena 2 (U.S.)	1,990	22-26
Delta 2 (U.S.)	1,982	45-60
Cosmos (Russia)	1,400	12-14
Taurus 1 (U.S.)	1,400	18-20
Pegasus XL (U.S.)	460	12-15
Insurance		7-72
Total		97-497
*To Low Earth Orbit.		

Sources: Commercial Space Transportation, U.S. Department of Transportation, Federal Aviation Administration, Washington, D.C. 1999; Jim Martin, "Key Cost Factors in Commercial Remote Sensing (Ground Segment)," Raytheon Systems Company, Arlington, VA., September 29, 1999; and Clayton Mowry, Satellite Industries Association, Alexandria, VA., September 28, 1999.

TABLE 9

Remote Sensing Applications:

CATEGORY		APPLICATIONS
Environment	Earth	Glacier Evolution
		Snow Cover/Runoff
		Forestry: evolution, diseases, fires, deforestation
		Agriculture: yield, damage assessment, diseases
		Surface Composition
		Artifacts, Urban Development
	Air	Temperature Profiles
		Humidity Profiles
		Trace Constituent Profiles
		Cloud Types
		Wind
		Pollutants
	Water	Temperature
		Currents
		Wave Spectra
		Contaminants
		Biological Activity
		Ice Cover
		Iceberg Monitoring
	Atmosphere	Conditions
		Solar Wind
		Aurora
		Ozone Monitoring
Military		Reconnaissance
		Missile Launch Detection
		Strategic and Tactical Planning
		Arms Treaty Compliance
Media		News Gathering
Cartography		Various Types
Humanitarian		Natural Disaster Assistance

Source: Hoversten, 2000.