Some Ethical Aspects of International Satellite Remote Sensing

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ABSTRACT: The world's quest for new natural resources can be greatly aided by satellite remote sensing. There are, however, a number of significant political, legal, and ethical issues which surround the functioning of such satellites. Some underlying concerns are rooted in the early military applications of aerial and orbital activities. Others have surfaced in extensive discussions within the United Nations.

The ASPRS Code of Ethics, the 1986 *UN Remote Sensing Principles*, and international space law can serve as a foundation for reflections and suggestions on ethical aspects of international satellite remote sensing activities. Special attention must be given to the needs of developing nations, especially their concerns about potentially detrimental uses of information derived from satellite remote sensing imagery by foreigners. In addition, everyone—from individuals to States to multinational organizations—should willingly and enthusiastically accept full responsibility for their remote sensing activities.

INTRODUCTION

WITH A RAPIDLY EXPANDING world population and material consumption rate, there is increasing pressure to find new natural resources as well as to monitor their development and the environmental impact of their development. Because a high percentage of the world's obvious and easily developed natural resources have already been discovered, the search for new resources tends to be concentrated in developing nations with large amounts of poorly explored land. Remote sensing satellites have great potential to assist this process.

The present situation with the international use of satellite remote sensing cannot be divorced from the beginnings of remote sensing, which are closely tied to military reconnaissance. This history, frequently combined with memories of colonial exploitation (Myers, 1987), raises serious concerns among many nations over whether the information derived from satellite remote sensing activities might be used to their detriment rather than to their benefit. During the last two decades, discussions in the United Nations and especially in its Committee on the Peaceful Uses of Outer Space (UN COPUOS) have explored in great detail the political, legal, and technical ramifications of non-military satellite remote sensing. Some of these discussions have resulted in formal treaties, others in declarations of principles, and still others remain open. The most noteworthy among these is the 1986 "Principles relating to remote sensing of the earth from space" (the UN Remote Sensing *Principles*). The following analysis assumes that, as the result of international consensus, those *Principles* represent the best foundation upon which the ethics of international satellite remote sensing activities might be elaborated.

A guiding principle of this discussion is that it is as important to know *why* nations hold and express the positions they do as to know simply *what* those positions are (Wasowski, 1978). The underlying premise is that governments—like individuals—are an inseparable mixture of the rational and the emotional. No comprehensive perspective can be obtained without seriously considering this empirical fact (Thiroux, 1986).

A BRIEF HISTORY OF REMOTE SENSING

The history of remote sensing is long and complex. Certain elements of that history, however, are especially important because of the influence they have on the politics, law, and ethics of satellite remote sensing activities.

AIR SPACE ACTIVITIES

The history of gathering information from elevated platforms is closely tied to military reconnaissance. Among the earliest known attempts at military aerial reconnaissance occurred in June of 1793, during the French Revolution. Tethered balloons were used as observation platforms, with success dependent on the training, skill, and courage of the observer. Some 65 years later, in 1858, the first known photographs from a balloon were taken by a Frenchman named Gaspard Felix Tournachon, better known by his pseudonym Nadar. Two years later, Samuel A. King and J. W. Black accomplished a similar feat in America by photographing Boston from a balloon tethered 1,200 feet above the city (Morenoff, 1967). Aerial photo reconnaissance for military purposes was conducted occasionally shortly thereafter, during the American Civil War. Kite-borne cameras as well as unmanned and manned balloons were used, such as at the Battle of Fair Oaks, Virginia, in 1862 (National Air and Space Museum, 1990).

The first photographs ever taken from an airplane were obtained by Wilbur Wright. Flying over Centocelle, Italy, on 24 April 1909, he used a motion picture camera to capture for his viewers the sensation of flying. Not long afterward, cameras were used in selected British flying schools to assist German aviation students with advanced flight training (Morenoff, 1967).

During World War I, infringement on national airspace became as important if not as frequent as infringement on the territory beneath. A certain freedom had been assumed because, up to that time, no international agreements had been reached over whether airspace was free for the use of all or under the sovereign control of the subadjacent State. World War I served as a strong incentive for the conclusion of such an international agreement. This happened at the 1919 *Paris Convention*, which unambiguously accepted a nation's sovereignty in the domain above all territory which it controlled. The *Paris Convention* was ratified by 33 nations, including all of the Allied Powers except the United States. A similar international agreement was discussed at the Fifth Pan-American Conference held at Santiago, Chile and subsequently accepted at Havana, Cuba on 20 February 1928. Article 1 stated *inter alia* that "The High Contracting Parties recognize that every power has complete and exclusive sovereignty over the air space above its territory" (Morenoff, 1967). Both the Paris and Pan-American conventions extended such sovereign rights even to nations that were not signatories.

Before World War II, the former Commander-in-Chief of the German army reportedly predicted that the side with the best

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aerial reconnaissance capability would win the coming war. In 1940, the German army had superiority in this regard. Effective employment of this capability was a principal reason for the degree of success of Luftwaffe raids against French airfields early in the war. As the war continued, however, the balance shifted markedly, with a relatively steady decline in the German aerial reconnaissance capability and a corresponding improvement in the British and American capability. The U.S. Army Air Force alone acquired some 171 million aerial photographs during World War II, substantially aiding the Allied victory (Morenoff, 1967).

Although World War II demonstrated the military importance of aerial imagery, even before the war ended the thoughts of many nations regarding a variety of activities conducted in air space began moving beyond security considerations toward economic ones. Delegates gathered in Chicago in 1944 and drafted the *Convention of International Civil Aviation* (the *Convention*). In hindsight, one of the most significant aspects of this *Convention* was the lack of any discussion of the implications of the German V-2 rocket, which had been used for several weeks before the delegates convened (Morenoff, 1967). The reason for this omission was almost certainly that, at the time, information about the V-2 was still classified "Top Secret." The net result was that a potentially new and important element relating to aerial activities was left open to years of informal discussion and unrestricted use. Nonetheless, the *Convention* reaffirmed every nation's complete sovereignty over its airspace. Article 36 of the *Convention* also granted contracting States the right to prohibit operation of imaging devices within its airspace (Mounts, 1987).

The next major event in the development of this legal regime occurred during the Geneva Summit Conference of 1955. On 21 July, in the course of that Conference, U.S. President Dwight D. Eisenhower proposed the *Open Skies* policy to the Soviet delegation. Its modern equivalent is currently under discussion between the Soviet Union and the United States. In essence, President Eisenhower suggested the possibility of avoiding armed confrontation by allowing peace-time ideological adversaries to fly aerial reconnaissance missions over each other's territory. It was no coincidence that Lockheed Corporation completed the first U-2 reconnaissance aircraft about one month later (Morenoff, 1967). No agreement was reached on *Open Skies* at the 1955 Geneva Summit Conference.

On 1 May 1960, a National Aeronautics and Space Administration (NASA) U-2 aircraft piloted by Francis Gary Powers left Pakistan on a military reconnaissance flight over the Soviet Union. It was shot down by a Soviet missile. After initial denials, the United States acknowledged the flight and its violation of international law. This seemed to provide the Soviet Union with an ideal opportunity to seek a World Court ruling on the legal status of very-high-altitude military reconnaissance. However, they chose to settle the case in their own courts under their own domestic laws (Morenoff, 1967).

Precisely two months later, on 1 July 1960, Soviet aircraft shot down a U.S. Air Force RB-47 military reconnaissance aircraft flying over international waters near the Soviet Union. In something of a role-reversal, the Soviet Union never claimed a legal right to shoot down a foreign aircraft flying over international waters, even if it were engaged in military reconnaissance.

Just as with the simultaneous completion of the first U-2 reconnaissance aircraft and proposal of the *Open Skies* policy, neither was it coincidence that important new remote sensing techniques became operational about that same time. One of these was airborne thermal infrared (TIR) imaging developed by the U.S. military under security classification. The ability of TIR sensors to "see in the dark" was something with obvious military significance. Interpreters with geologic and geographic backgrounds, however, soon recognized that many physical characterisitics of the Earth's surface not at all evident in other types of remote sensing imagery were remarkably obvious in the TIR imagery. Similarly, side-looking airborne radar (SLAR) imaging systems became operational in the mid-1950s. These were capable of acquiring military reconnaissance data over hostile territory regardless of cloud cover and without the necessity of risking overflight of that territory. SLAR too revealed much unique information about the geographic and geologic character of the land surface.

As a result of the versatility of these new image types, declassified TIR and SLAR imaging systems were incorporated into the design of non-military remote sensing satellites. Because so much remote sensing technology has been derived from the military, it is clear that many political, legal and ethical concerns are by no means without foundation.

Outer Space Activities

In rather sharp contrast to the development of aerial photography, the very beginnings of space remote sensing were primarily non-military, although that situation soon changed.

Non-military Activities. On 29 July 1955, the United States formally announced its intention to initiate an Earth satellite program as part of the coming International Geophysical Year (IGY, from July 1957 through December 1958). The immediate reaction was one of widespread approval, with many world leaders expressing enthusiastic endorsement of the IGY concept. Even though no preliminary international agreements had preceded the announcement, not one nation issued a protest to the planned satellite program (Morenoff, 1967).

To the world's amazement, the Soviet Union was the first nation to actually orbit a satellite: Sputnik-1, launched on 4 October 1957. The United States soon followed with Explorer-1 on 31 January 1958. Even after numerous other satellites had been launched, no notable objections were raised that their overflight might constitute a violation of territorial sovereignty. Thus, as a result of prolonged unchallenged practice, it became *customary international law* that any nation capable of orbiting a satellite had the right to overfly any other State with that satellite without first seeking permission. However, not everyone agrees that lack of protest about space activities should be interpreted as lack of serious concern (Konstantinov, 1984). Some still claim that they might have objected strenuously had they been better informed about all the relevant facts (Hingorani, 1988).

The success of the IGY was predicated on cooperative research and open data sharing between all involved parties. The United States provided extensive advance details on satellite design, instrumentation, and telemetry patterns, as well as up-to-date orbital elements to allow precise tracking and direct data reception by any interested nation. By contrast, the Soviet Union provided very little advance information about its space activities and greatly restricted both the type and amount of data released. During the June 1963 meeting of the Committee on Space Research (COSPAR) held at Warsaw, the United States reported cooperative space activities with more than 60 nations, while the Soviet Union did not mention cooperative space activities with even one other nation (Frutkin, 1965). All of this drew a strong contrast between the U.S. civilian space agency, NASA, with its explicit charge of sharing the benefits of space exploration (Codding and Beheshti, 1973), and the predominantly military and therefore closed Soviet space program. Numerous events of the past quarter-century have greatly softened this contrast, ranging from Soviet marketing of orbital Earth photography to serious U.S. consideration of assigning responsibility for Landsat-7 to the Department of Defense. Nonetheless, the early activities set the stage for two very different philosophies of space activity that were often heatedly debated.

Military Activities. The early emphasis on geophysical satellites

did not last long. Even as President Eisenhower proposed the *Open Skies* policy in 1955, the U.S. reconnaissance satellite program was being initiated. It reached the flight stage with the launch of Discoverer-1 in 1959. The Discoverer series was primarily a feasibility study of using Earth-orbiting platforms to gather military reconnaissance data. Together, the world's two space powers had established the age of satellite monitoring (Mounts, 1987). On 24 May 1960, the first Midas (Missile Defense Alarm System) satellite was launched. Project Midas carried TIR sensors designed to detect missile launches and provide advance warning of an attack. There were reports during 1960 that the United States had also begun launching the Samos series of satellites. Samos returned film exposed through very-high-resolution cameras, with results reportedly superior to any received from the U-2 flights that were officially terminated that same year (Morenoff, 1967).

Initially, the Soviet Union was extremely vocal in objecting to space-borne reconnaissance. The philosophical basis for these objections was the assumption that *any* gathering by *any* means from *any* altitude of *any* information which they desired kept secret was automatically espionage and therefore illegal.

As late as May 1963, the Soviet jurist G. Zhukov had asserted that "the concept of the 'peaceful use' of outer space excludes any measure of a military nature." However, this position was apparently modified during the 13 May 1963 meeting of the Legal Sub-Committee of the UN COPUOS. There, the Soviet representative declared that his government would not feel limited to non-military uses of space until an international agreement on complete disarmament had been reached (Soraghan, 1967). Indeed, the U.S.S.R. launched five recoverable reconnaissance satellites in 1962, eight in 1963, and 11 in 1964. On 8 November 1963, the U.S. and U.S.S.R. formally agreed that, among other things, all future spacecraft would be allowed to have photographic apparatus (UN COPUOS, 1976). This was a major review of Article 36 of the 1944 Chicago *Convention* applicable only to satellites. Finally, on 28 May 1964, Soviet Premier Khrushchev publicly admitted to U.S. Senator Benton that his nation had "spying" satellites (Morenoff, 1967).

In short, military applications of space technology– especially remote sensing–quickly overshadowed the initial peaceful applications. Thus, developments in satellite remote sensing further fueled the political, legal, and ethical concerns of many nations.

THE UNITED NATIONS DISCUSSIONS

As early as 1958, there were serious discussions in the United Nations General Assembly (UN GA) which indicated that the infant science and technology of outer space exploration was of concern to almost all nations. As a result, on 13 December 1958 the UN GA established an *ad hoc* Committee on the Peaceful Uses of Outer Space (UN COPUOS) in UN GA Resolution 1348-XIII. In its first session, the UN COPUOS decided *inter alia* that two working groups would be needed (the Technical and Legal sub-committees) and that all issues would be decided by consensus. In 1962, the UN COPUOS became a permanent standing committee.

Contrary to some expectations, the most difficult discussions usually occurred in the Legal rather than in the Scientific and Technical Sub-Committee (Frutkin, 1965). One of the earliest proposals set before the Legal Sub-Committee was presented on 20 June 1962 by the Soviet Union. This draft declaration stated *inter alia* that "use of artificial satellites for the collection of intelligence information is incompatible with the objectives of mankind in its conquest of outer space" (Fawcett, 1968). However, it soon became apparent that it would be impossible to restrict outer space to non-military uses, so the impetus turned toward encouragement of non-aggressive (i.e., peaceful) uses. This is reflected in the first major document to come from the UN COPUOS, the "Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space" adopted on 13 December 1963. Three years later, on 19 December 1966, the "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies" (the *Outer Space Treaty*) was adopted.

Both of these U.N. documents are notable because no mention is made of military satellite reconnaissance, even though the issue had been raised in the discussions. More remarkable still is the fact that the issue of non-military observational satellites was never even considered in the Treaty discussions (Fiorio, 1973). As a result, the *Outer Space Treaty* left completely open the legal and ethical implications of using non-military satellite remote sensing systems. There followed a great deal of debate about which of the *Outer Space Treaty's* articles (if any) would be most appropriate as a foundation for a remote sensing agreement. A unanimous U.N. Resolution of 29 November 1971 established the "Working Group on Remote Sensing of the Earth by Satellites" (Galloway, 1973). With the establishment of Legal Sub-Committee Working Group III, the decision to move in the direction of a formal international agreement on non-military satellite remote sensing was finalized. The *Principles*, however, were 15 more years in coming.

The first written proposal to regulate remote sensing activities was submitted in 1970 by Argentina (UN COPUOS, 1970). However, the issues that dominated the UN COPUOS discussions of non-military satellite remote sensing are contained in five draft proposals submitted in 1974 for the Thirteenth Session of the Legal Sub-Committee. By the time of the 1975 UN COPUOS session, these had been consolidated into three draft proposals: a Franco-Soviet one, an Argentine-Brazilian one, and an American one. Each had its own concerns and philosophical justifications. By far the most significant difference between the three drafts lay in the proposed regulations governing the rights of States to acquire and dispose of data and information obtained from remote sensing satellites.

THE 1975 FRANCO-SOVIET DRAFT RESOLUTION

Among the stipulations of the 1975 joint Franco-Soviet draft was that:

> A state obtaining information on the natural resources of another state in the course of remote sensing shall not have the right to publicize it without the clearly expressed agreement of the state to which these natural resources belong or to utilize it in any way to the detriment of such a state (Bordunov, 1975).

The record of the discussions clearly indicates that France and the Soviet Union both tied the use of remote sensing satellite data to the principle of respect for territorial sovereignty. But a novel element was added:

> ...the sovereign rights of states to dispose of their own natural resources and information about those resources... . Of the total set of such questions, the most important is that of protecting the rights of states with respect to information on their natural resources (Bordunov, 1975).

The 1975 joint Franco-Soviet draft thus introduced the concept of *informational sovereignty*, which was claimed as an "inalienable" right (Polter, 1976).

THE 1974 ARGENTINE-BRAZILIAN DRAFT RESOLUTION

The 1974 Brazilian draft was in some ways very similar to the Franco-Soviet draft, in particular with its proposed restriction against transfer of any data to a third nation without prior consent (Polter, 1976). But the draft went even further, saying *inter alia* that

> States parties shall refrain from undertaking activities of remote sensing of national resources belonging to another State party, including the resources located in maritime areas under national jurisdiction, without the consent of the latter (UN COPUOS, 1974).

This would have imposed the condition of prior consent before a nation's territory could even be sensed.

Attempting to understand the reasons for these suggested prohibitions, some observers drew a parallel between space and maritime research. Many Latin American States have long been sensitive about foreign research activities in their continental shelf waters, concerned about potential economic exploitation of scientific discoveries and about the use of research as an outright subterfuge for exploitation. Some of these States are concerned that the same will happen with satellite remote sensing (Hingorani, 1988). Others suggested that many Latin American nations still had vivid and bitter memories of being stripped of their most valuable resources for the benefit of their former colonial masters. In short, some nations are concerned that other nations might learn more about their resources than they themselves know, and then use that knowledge to their economic or political detriment.

The Argentine-Brazilian draft of 15 October 1974 (*cf.* UN GA First Committee, 1974) expanded upon the earlier Brazilian draft, in particular to mention the need to avoid "spoilation or destruction of the environment" as well as to respect ownership of the resources themselves.

The common element uniting the Franco-Soviet and Argentine-Brazilian draft resolutions was control of information: its acquisition, its dissemination, or both.

The 1975 United States Working Paper

The U.S. working paper was centered around the concept of freedom of information. Two elements were essential to this view: that every State had the right to sense every other State from space without prior consent, and that all sensed data should be made openly available as part of an *international public domain*. One justification for unlimited access to data and the ability to analyze the data was that the chances for unexpected and undesired exploitation would be increased where checks and balances were limited. This philosophy had already been translated into practice with the Landsat data distribution policy, which was retained in the *Land Remote Sensing Commercialization Act* of 1984. That policy mandates direct access to the satellites themselves via regional ground stations together with unrestricted, timely distribution of all data at reasonable cost.

Discussions Leading to the 1986 *Principles*

While recognizing the benefits of satellite remote sensing, many nations remained wary of potential abuses. The issue of international responsibility had been addressed in the *1966 Outer Space Treaty*, but it again became critical because of acute awareness of the intrusive aspects of satellite remote sensing activities (Christol, 1988). There was a growing understanding that it was the dissemination of information, not the acquisition of data, that posed the greatest threat. In 1982, Brazil submitted a proposal that *inter alia* declared:

> A State conducting remote sensing activities on Earth shall be held internationally responsible for the dissemination of any primary data or analyzed information that adversely affects the interests of a sensed State (UN COPUOS, 1982).

This had a very significant impact on subsequent UN COPUOS discussions of satellite remote sensing and eventually resulted in acceptance of international responsibility. Without it, the UN COPUOS might never have achieved consensus on the 1986 *Principles* (Christol, 1988).

ETHICAL ASPECTS OF SATELLITE REMOTE SENSING ACTIVITIES

Just as the preceding sections did not presume to be exhaustive, neither does this one. Rather, the following discussion of ethics is intended to be a first step in asking some questions and suggesting some answers regarding diverse international satellite remote sensing activities.

Ethics

Some define *ethics* as action in conformity with a consistent definition of what is right or just. Others would simply say that *ethics* is *moral action*.

Ethics need not be based on religious belief, although every religion has at least an implicit code of ethics. Religious-based ethical systems may be developed primarily from supernatural beliefs (e.g., in Judaism and Christianity), almost exclusively from social aspects (e.g., in Buddhism and Confucianism), or any combination of these (Thiroux, 1986).

Secular ethical systems may also be developed from a wide variety of sources. It is difficult enough to develop a moral foundation for ethical behavior within a single nation and culture, where common experiences and values aid reaching a consensus. It is nearly impossible to define a global moral foundation for ethical behavior, where there may be little shared history and values. Attempting to seek common ground with both religious and secular moral systems, Thiroux (1986) suggests five basic moral principles: the value of life, goodness, justice, honesty, and freedom.

In the world of international relations, the most common foundation for ethical norms is consensus about which values are most important to most nations. Ideally, this would be the *common good*, about which there is seldom agreement. Practically, this is the *common interest*, about which consensus can sometimes be reached (Christol, 1984). To Thiroux's five basic moral principles, Rajan (1978) would add five basic elements of *national common interest:* the State's security and territorial integrity, sovereignty and independence, desire to retain and expand existing power, desire to maintain or increase living standards, and desire for membership in international organizations of near-universal membership (e.g., the United Nations).

As U.N. discussions clearly demonstrate, consensus on issues of common interest always requires extended airing of views and values, of reasons and perceptions, combined with a substantial amount of give-and-take from all sides (Gaggero, 1987). To whatever extent such consensus springs from common interests and describes not simply what people do but what they *ought* to do, then it might be said that the consensus provides a moral foundation for ethical behavior.

Some might ask why anyone should act with anything but unadulterated self-interest in mind. Brown (1987) answers:

> One's own interests are not to be sacrificed, but the important lesson is that others have interests too, and rights, and the moral task is to try ever harder to rise above a fundamental impulse to do whatever one wants to do, regardless of others... .

Because satellite remote sensing activities are so heavily dependent on technology, some might also ask why such activities should be the subject of ethical scrutiny. Many would agree that technology *per se* is ethically neutral but is nonetheless ethically significant because of the ways we use or misuse it (Partridge, 1980). The technical possibilities for the future are almost limitless; which of them *ought* to be chosen is a question of morals; how we implement them is a matter of ethical behavior and, sometimes, law (Stone, 1987).

The relationship between ethics and law must also be addressed. History shows that morality usually precedes law, while law codifies morality by mandating what has come to be accepted as the ethical way to behave in a given culture (Thiroux, 1986). Because no codified law perfectly embodies the spirit with which it was drafted, and because only some aspects of morality are codified in law, ethical behavior will typically go beyond the letter of the law to embody its spirit.

Ethics and Satellite Remote Sensing

Because this discussion of ethics and satellite remote sensing is held in the context of the American Society for Photogrammetry and Remote Sensing (ASPRS), the *ASPRS Code of Ethics* (the *Code*) is a natural starting point for detailed reflections. Unfortunately, the *Code* was not drafted with international satellite remote sensing activities specifically in mind. Nonetheless, two points serve as excellent guides to ethical professional behavior in this arena. First, the opening three words are "Honesty, justice and courtesy... ," the basic ideals upon which both the ASPRS and the *Code* are built. Ethics are ideals in action. Second, the *Code* is explicitly a set of active guidelines of what is right and just springing from within, not a set of passive guidelines imposed and enforced from without. The general tone of the *Code* will guide the following comments and suggestions.

Precisely because ethical systems are usually developed from commonly held values and because the *UN Remote Sensing Principles* were produced by consensus in the UN COPUOS and unanimously approved by the UN GA, the 15 *Principles* are eminently worthy norms for ethical behavior.

Principle I provides five technical definitions relevant for all subsequent principles.

The definitions of "remote sensing" and "remote sensing activities" emphasize improving resource management, land use, and environmental protection. The *Principles* thus begin on a strong positive note. One clear ethical implication very much in accord with the ASPRS *Code* is that satellite remote sensing activities in the broadest possible sense should always be constructive for every affected party, not simply lucrative for those conducting the activities.

The three definitions related to data and information make distinctions that were extensively debated during the UN COPUOS discussions. The perceived need for these definitions is a vivid reminder that non-discriminatory *processed data* and *analyzed information* distribution is an extremely sensitive issue and thus must always be considered from an ethical perspective. Given the recognition that *analyzed information* has by far the greatest potential to harm sensed States, a clear ethical implication is that professionals engaged in value-added remote sensing activities should be very sensitive to potentially detrimental consequences of their work. This idea is elaborated in *Principle IV*.

Principle II emphasizes that the benefits of satellite remote sensing shall be derived "in the interests of all countries," especially the developing nations. One ethical implication is that the special needs and concerns of developing nations should always be a significant (though not necessarily determining) factor in conducting international satellite remote sensing activities.

As the U.N. discussions indicate, questions remain regarding whether development of any resources would be primarily for the benefit of the host nation or of the developer. Existing agreements clearly indicate that the interests of both parties must be given due consideration. On the one hand, the host nation has certain rights regarding both the conditions governing the development and disposition of the resources and the wealth derived from their sale. These rights were addressed as early as UN GA Resolution 1710(XVI) of 19 December 1961 (Rajan, 1978). On the other hand, the developer has the right to make a just profit for the use of its capital and expertise. Some ethical questions arise regarding how much visiting experts should be paid for their participation, how many local workers should be employed, how much their skills should be improved, and how well paid they should be. With few exceptions, the host nation will have a lower standard of living than the guest nation or corporation. It seems that any remote sensing activities should include conscious efforts to improve the living standards of the host nation's workers.

Principle III reiterates that "[r]emote sensing activities shall be conducted in accordance with international law... ." This is a clear reminder that all persons (including corporations) are individually bound by the international laws that collectively bind their nation. The fact that international space law is not fully mature can never serve as an excuse for borderline practices. Also, even though these *Principles* do not have the force of law, they should be given very serious consideration precisely because they represent unanimous international consensus.

Principle IV refers to three stipulations of Article I of the 1966 *Outer Space Treaty*, answering in part the question of which *Treaty* articles would most directly apply to satellite remote sensing activities. The first reference was the source of *Principle II*. The second reference recounts that the freedom of outer space exploration and use is conditioned on equality among States. The third reference mandates respect for the sovereignty of States and peoples over their wealth and resources, and that "activities shall not be conducted in a manner detrimental to the legitimate rights and interests of the sensed State."

In general, territorial sovereignty would seem to be safeguarded by the need for ground truth, i.e., fieldwork confirming an interpretation of the sensed area. However, contrast, edge, and color enhancement procedures all improve the photo-visual interpretability of imagery. SPOT stereoscopic coverage can further aid interpretability. Digital resampling techniques are improving so that very little spectral information is lost in this process. And improved multispectral classification algorithms are yielding more accurate information extraction from the satellite image data. Together with improved resolution of forthcoming sensor systems (e.g., Landsat-6 and SPOT-3), ground truth requirements will decrease and territorial sovereignty concerns may increase.

Following on the definitions of "data" and "information" in *Principle I*, value-added remote sensing professionals should seriously consider not marketing information about a sensed State to any other State that would likely use that information in a detrimental way.

Principle V emphasizes that States with remote sensing programs should widely promote international cooperation and participation in those activities, based on "equitable and mutually acceptable terms." This principle places a positive responsibility not only on States but also on their nationals to initiate cooperative activities intended both to benefit the cooperating States and to improve the science and technology of remote sensing.

Principle VI emphasizes that States are encouraged to establish regional receiving and processing stations in order to "maximize the availability of benefits from remote sensing." This is clearly the responsibility of the satellite system operators and has been recognized by both EOSAT and SPOT Image Corporation as in their best interests for marketing of satellite image data.

One potentially critical ethical concern involves the conditions of availability of satellite imagery products. Assuming the current Landsat and SPOT *open skies* marketing policies, it would stretch the limits of ethical norms to price image products so high that only the rich could afford them. On the one hand, the free market determines the true value of the image data based on the benefits of using the extracted information. On the other hand, the satellite system operator sets receiving station fees and image product prices based on such considerations as the volume and certainty of expected sales in all market segments. Setting prices primarily in response to high volume users (e.g., military contractors with essentially unlimited budgets) could result in effectively forcing developing nations out of the market. This would at best constitute failure to take special account of the needs of those developing nations and at worst give *open skies* little practical meaning.

By no means are the only ethical issues regarding data availability directed toward the satellite system operator. In the early Landsat years, the data were considered public domain and thus could be freely copied and disseminated. But it became clear that commercial satellite remote sensing operations would be viable only if data distribution could be legally regulated, whether as intellectual property, under copyright, or some other binding arrangement (Oosterlinck, 1984). Users of satellite remote sensing imagery products are ethically obliged to abide by all proprietary conditions included in the purchase agreement.

Principle VII encourages technology transfer. "eyond offering value-added services, technology transfer at all levels—individuals to governments, basic visual to advanced digital interpretation capabilities—is one aspect of remote sensing activities already attracting substantial interest.

Highly specialized state-of-the-art computer technology, such as digital image processing, is often subject to a time lag between development and dissemination. This is not necessarily the result of deliberate withholding of the technology, but can be a natural consequence of so much happening so quickly that only a few experts can keep abreast. Left alone, this situation tends to favor rich nations and corporations over developing nations. From the perspective of justice, it might be ideal for a professional society (e.g., the ASPRS) or a commercial publication (e.g., *Computer Graphics World*) to serve as a clearinghouse for current information on remote sensing and GIS computer hardware and software. Particular attention might be paid to objective comparisons of software capability and value, as well as reports on systems under development. This would not only help alleviate the difficulties non-experts encounter in keeping current but also stimulate improved quality and value in digital image processing systems.

The development of computer software for satellite image processing is itself an area where ethical issues can arise. The software market is limited, so prices are high. Even though developing nations with severely limited means may be unable to purchase the best software for every available computer, they are ethically bound to abide by the conditions established by the software distributor. An image processing facility may have to purchase software with somewhat limited capabilities or execution speed. However, having legitimate essential capability is ethically preferable to having pirated advanced capability.

Another possible area of ethical concern is the specific implementation of image processing algorithms. Most basic algorithms are public domain. However, the specific implementation of an algorithm in a given computer language on a particular processor chip will inevitably vary from one software producer to another. These implementation will seldom if ever be protected by international copyright. Nonetheless, ethical standards require abstinence from all efforts to copy the specific implementation of an algorithm, e.g., by decompiling a foreign competitor's executable code.

Principle VIII mandates the United Nations and its appropriate agencies to be actively involved in satellite remote sensing activities. This cannot be implemented without appropriate external support. Wealthy nations and corporations have an ethical obligation to seriously consider providing assistance (e.g., funding or expertise) that would make such U.N. agency activities possible.

Principle IX reiterates the obligation of States with satellite remote sensing programs to inform the U.N. Secretary General of as many relevant facts as possible. This was originally intended to include things such as satellite orbital parameters, communication frequencies, data formats, availability, and pricing. Perhaps this should be expanded to include a comprehensive and timely listing of all image purchases so that every sensed State would know who is gathering information about its territory, including its own nationals. This would clearly be the responsibility of satellite system operators. Sensed states might obtain this information from either the Secretary General or the system operator, and either automatically or upon request. Although some might perceive this as a violation of privacy rights of imagery purchasers, the *Principles* clearly indicate that the economic needs of sensed States would normally have priority.

Principle X advocates environmental protection with special care taken to provide affected States with information that might avert harmful environmental phenomena. History indicates that this principle may be particularly susceptible to ethical abuse, because it is usually much easier to opt for development with minimum rather than maximum environmental protection. In addition, some assert that our moral and ethical responsibilities go beyond our own generation, that we *ought* to leave the world fit for human habitation and worthy of the human name for all future time (Partridge, 1980; see also Brown, 1987). Remote sensing professionals should hold this as a strong positive ideal.

Because *Principle X* is directed only to *nations* that possess new environmental information (DeSaussure, 1987), some might argue that individuals and corporations are not ethically bound by this principle. However, it can also be argued that it is in the spirit of this principle for those professionals to communicate all such environmental information derived from remote sensing analyses.

A prime example of environmental information is that concerning massive clearing of tropical rainforests, which lie predominantly within the sovereign territory of developing nations. Satellite remote sensing provides a fast, reliable, and economical way of monitoring activities in these vast areas with difficult access. But these systems have finite abilities to acquire, transmit, and store data. Commercial enterprises have an ethical responsibility to make a profit for their stockholders. Thus, a satellite system operator may decide against acquiring all possible images of environmentally sensitive areas if such imagery is unlikely to be purchased, in favor of acquiring images of potential resource areas where data purchase is likely or even guaranteed. There seems to be no definitive ethical answer. A middle ground might be reached that includes acquisition of one image per tropical rainforest scene per year. In addition, this might be an ideal area for sensing and sensed States to establish cooperative applied research projects.

There is still another issue with regard to use of tropical rainforest imagery. As evidence mounts that alteration of regional rainforest environments might affect the global environment, extreme political and economic pressure might be brought to bear on the nations controlling those environments. Without assurances of financial and technical aid, rainforest nations might reluctantly conclude that they have no realistic alternative to food and timber production except to continue clearing the rainforests.

Principle XI is very similar to *Principle X*, except that it is oriented specifically toward natural disasters. One example would be a geologist using SPOT stereoscopic imagery who discovers a previously unknown and potentially dangerous fault. Another example would be a hydrologist using Landsat TM TIR imagery who discovers a thermal anomaly that might indicate an imminent volcanic eruption. *Principle XI* puts a positive ethical obligation on remote sensing professionals to insure that all such image-derived information is quickly conveyed to all affected nations. If the potential disaster would seriously affect the well being or livelihood of people, that obligation might even supersede any potential benefits the information's owners might derive from keeping the information proprietary.

Principle XII asserts that all sensed States shall have non-discriminatory access not only to all data but also to all information

derived from satellite imagery of its territory. Again, special attention should be paid to the needs and interests of developing nations. This principle may provide some of the most difficult ethical questions for value-added professionals, precisely because it explicitly includes the information extracted from the imagery. On the one hand, if a nation or corporation pays to have information extracted from satellite imagery, it can argue convincingly that it alone has rightful access to that information. Such a corporation might be concerned that revealing the image-extracted information to the sensed nation might lead to that nation developing the found resources themselves or granting development rights to a different corporation or nation. Ethical considerations would seem to admonish both sides to deal fairly with each other, in ways that are clearly deserving of trust.

A proposed independent system called *Mediasat* has potentially great ethical implications for dissemination of information derived from satellite remote sensing. The concept of media use of satellite imagery goes back to the 1960s. However, it came to full flush with the Chernobyl nuclear reactor accident, when both Landsat Thematic Mapper and SPOT Multispectral images were extensively used. No one seriously contests the right of news organizations to use satellite imagery as long as the purpose is accurate, complete, and timely news coverage. An ethical issue of growing concern is that the media might not only report the news, but create or even become the news. Courts in the United States have held that information gathered for purposes of news reporting may be published unless its release presents a "clear and present danger of substantial and irreparable harm" (Sloup, 1987). The UN COPUOS discussions clearly indicate that potentially dangerous or harmful revelations of accurate information are a deeply felt concern of many nations. It has been argued that some level of "hysteria" was generated by some inaccurate media interpretations of Chernobyl satellite imagery (DalBello and Martinez, 1987). It thus seems that ethical media behavior should also include considerable precautions regarding the release of image interpretations that are not substantiated by at least one remote sensing expert. This would be especially true when a nation's economic or political security might be at stake, where it is possible to make revelations about sensed States that are more than just embarrassing (Sloup, 1987).

Principle XIII is similar to *Principle V* in encouraging international cooperation but different in granting initiative to the sensed rather than the sensing State. Given available time and money resources, remote sensing professionals should neither avoid nor resist international cooperation but instead welcome it, especially when critical needs of developing nations are at stake.

Principle XIV recalls Article VI of the *Outer Space Treaty* in affirming that the launching State bears ultimate international responsibility for remote sensing activities, even if those activities are conducted by non-governmental entities. Given one perception of the litigious character of modern American life—it's anyone's responsibility but my own—some might be tempted to interpret this principle as placing the entire burden for ethical satellite remote sensing activities on the government. Quite the contrary, *Principle XIV* is more accurately interpreted to mean that the host government bears ultimate (i.e., last) responsibility for such activities, with remote sensing professionals, corporations and societies bearing first responsibility.

Principle XV simply states that disputes shall be resolved peacefully, using generally established procedures. It thus encourages all involved parties to actively seek rather than passively resist quick and equitable solutions.

SUMMARY AND CONCLUSIONS

The political, legal, and ethical issues surrounding international satellite remote sensing activities have a long and complex history. Complete definition and satisfactory resolution of all these issues is nowhere in sight. Nonetheless, the ASPRS *Code of Ethics*, U.N. resolutions, and international space law together provide a solid foundation upon which to describe ethical international satellite remote sensing activities.

Because they result from a broad-based international consensus, the 1986 *UN Remote Sensing Principles* serve as an excellent source of reflections on the ethics of satellite remote sensing activities. Like those *Principles* (Gaggero, 1987), the reflections offered here are only a beginning and bear no compelling weight. Zwaan and de Vries (1987) have suggested development of a formal and therefore more compelling "Code of conduct for the dissemination and distribution of data acquired by remote sensing of the Earth from outer space." As experience shows, the most viable forum would be the United Nations. But as the major U.S. society of remote sensing professionals, the ASPRS can and should play an important role in moving toward a formal code of ethics for international satellite remote sensing activities.

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