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SATELLITE IMAGERY CONTROL: AN AMERICAN DILEMMA

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Foreword

By Gordon Adams[1]

Space is no longer a frontier, used and occupied solely by governments. From an environment in which only governments operated, largely for exploration and military purposes, space has rapidly filled with assets used for intelligence and military operations to civilian communications, to observation and commerce. Today, more launches are dedicated to commercial purposes than to military ones.

The evolution of space from a frontier to an operating environment shared by multiple users from many nations has raised an entire new agenda of issues for policy makers. One of the most striking space developments of the past decade has been the growth of private sector developers and users of imagery from space, once the exclusive preserve of governments and their intelligence arms. DigitalGlobe launched its high-resolution satellite in the fall of 2001, and there is now nearly half a dozen commercial imagery systems circling the earth.

It is not easy to separate out the government and private sector policy issues concerning the environment or space, either for the United States or for others nation developing their own space activities. The appearance of commercial observation systems has ended government monopoly on such information and broadened the options for government and private users around the world. In 1994, the Clinton administration issued a presidential directive seeking to exercise some control over the expanding private sector activity in observation and imagery. Few of the Clinton policies have been tested, and some, such as shutter control, have raised strong criticism. The Bush administration is reexamining this area of policy today, a reexamination that has also provoked concern.

The concern grows from the realization by the U.S. government that space is an increasingly important operating environment for military operations. The military has come to rely intensely on space-based assets for imagery, target identification, missile

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guidance, location and weather information for military operations, and, above all, secure communications. It uses both dedicated military and commercial capabilities for many of these purposes. As the Space Commission, chaired by now Secretary of Defense Donald Rumsfeld, recognized, space is no longer marginal to the military; it is integral to their operations. This focus on the military utility of space will grow over the next few years as the conclusions of the Space Commission report are implemented, and as the administration's commitment to ballistic missile defense comes to include space-based sensors and, conceivably, space-based intercept capabilities.

The military is concerned about force protection, ensuring its increasingly critical assets can be defended. A defensive capability inevitably brings in its train an offensive capability. Hence the concern: how to ensure adequate protection without provoking an arms race in space. The growing commercial presence in space is drawn, inexorably, into this argument; for commerce and the military share the operating environment, even some of the tasks.

The question of public and private imagery is a microcosm of this broader debate. Here too the issues are not simple. For example, even private imagery developers cannot currently survive without public subsidy - through demand for their product and support for research and development of interpretation software. Are such subsidies appropriate; should the government rely solely on its own dedicated assets; should subsidization give government users special access, privileges and control? Given the growing sophistication of such imagery, should the government rely on private providers? Should the government then protect private providers as part of a space defense system, or does this interdependence run risks for the private providers, as their assets come to be seen by potential adversaries as targets in space?

These broad policy issues involve the public's access to information, the use of public funds to subsidize private purposes, and the risks to private operators of the growing reliance of the U.S. military on space operations. There remains precious little debate in the United States or internationally about these issues; they tend to remain in the hands of specialists. As both private and military users of space expand their activity, it

is critical to have resources in hand that inform the broader debate. Laurence Nardon's paper makes an important first step in this direction, and provides a valuable tool for policy-makers grappling with these issues.

Abstract

What happens when an information technology moves from being used exclusively by government intelligence agencies to being made widely available?

Satellite imagery, which has been kept secret since the time of the cold war, is now being marketed by companies with orbit observation systems. Though the economic success of these companies is still unconfirmed, the emergence of imagery on the international scene is already causing problems. Imagery allows for richer and more precise information to be distributed. The relations among states are developing in a more transparent environment, which would have both stabilizing and destabilizing effects.

What consequences should be feared in particular? The United States, because of the important role its companies play in developing this market and because of their great involvement in international affairs, is facing a dilemma: it wants to control this source of information for security reasons, while allowing its companies to become dominant in the new market.

How much leeway should it give the image suppliers? What financial support should it provide to the companies?

Very diverse mechanisms for control of satellite imagery have been considered to address the possibility of destabilizing or aggressive use of the imagery. At the beginning of October 2001, the government replaced them on short notice with a very innovative measure. By buying on an exclusive basis all of the satellite photos of Afghanistan taken by the only company that currently produces high-resolution commercial imagery, the Pentagon is preventing other parties from gaining access to this source of information, while providing considerable financial support to the company. An agreement similar to a buyout will be proposed, and undoubtedly accepted, by US companies entering this market in the future.

This kind of action confirms the importance of the connection between the US commercial imagery companies and the federal authorities. It does not appear to favor

the emergence of mass private demand, which is the only thing able to ensure market operation according to the private sector rules. This action does not settle the question of foreign imagery companies, which will definitely not accept the exclusivity contracts proposed by the US Department of Defense.

In a working group formed last spring, the new Administration continues to consider how to control the distribution of images in times of international crisis. It is now facing such a case on a major scale.

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Introduction

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a- Transparency

For decades now, information gathering and communication systems have been spreading throughout society. With faxes, cell phones, video cameras, and computers with Internet and e-mail access, our daily life has been transformed by devices allowing us to know and to make known, instantly and permanently. Less visibly, observation, data relay or telecommunications satellites support this transformation and participate in it actively.

In the information world, privacy and confidentiality are harder to maintain. Successful concealment of nuclear test sites, of violation of the rights of man or simply the dumping of oil into the ocean has become unpredictable. An incriminating image may be broadcast on the Internet and seen by the whole world in minutes. News circulates with no regard for borders and to a great extent escapes traditional state control. Several years ago, the Gilles Perrault book *Our Friend the King* [*Notre ami le Roi*], which denounced the regime of King Hassan II in Morocco, had been banned in that country. It was widely distributed in Morocco by fax from France.

The effect of this information *transparency* on the distribution of power in individual societies and more broadly throughout the world has just begun to be analyzed[1] and its impact will continue to be felt in the years to come.

The conduct of international relations is affected by this evolution. Some positive effects may be expected: a state will hesitate to adopt an objectionable position if it cannot remain hidden. More available information also means less uncertainty and more confidence in relationships between states.

In a recent work, the American author David Brin explains how a permanent system of surveillance of the citizens of a society can act as an instrument of liberation and as the way to exercise true direct democracy, giving the citizens control of the surveillance system.[2]

Brin counters the theses of Michel Foucault, for whom organized surveillance in a society can only be an instrument for oppression of the individual.[3] The dissemination of information could indeed have negative consequences. In relations between states, transparency could destabilize the governments and trigger conflict.[4] This is the kind of risk the United States now wishes to address. The country needs to find ways to adapt to the new risks caused by the ongoing availability of information.

b- Space Observation

Among the various information technologies transforming society today, space observation is special from several different perspectives.[5]

Because it comes in the form of an image, showing real objects, this information technology seems to be directly comprehensible and has an immediate impact on those seeing it. For example, the images of the city of Grozny taken before and after the Russian military campaign in the winter of 2000 immediately strike us with the violence of the destruction that took place in the intervening time.[6] The images are thus more meaningful than a series of numbers, more indicative than a text or a speech.

This impression that the image has an evident meaning is not without its problems. It is hard not to interpret an image by relying on preconceived ideas, which could lead to mistakes. This tendency to project assumptions led an expert to compare interpretation of space imagery with Rorschach tests which, in psychoanalysis, help patients express their unconscious ideas through the use of random inkblots.[7] So, because during the cold war US intelligence officers believed the Soviets were engaged in the arms race, they tended to read into images from Russian territory the general and continued growth of military installations.

This risk is all the greater because one would naturally give credence to information that seems visually evident. Images have a powerful and complex psychological impact on those seeing them.

These psychological components add to the real technical difficulty in processing and interpreting properly the images taken from space.

On the other hand, this technology, more than others, remains under the control of the US military leaders or intelligence officers.

Most information technologies have always existed in the public domain. Telephones, cameras, photographic equipment and faxes have always been used by civilians. Created under DARPA (Defense Advanced Research Projects Agency), computers and e-mail quickly became available to the general public. On the other hand, high-resolution space observation was developed by the intelligence services of the US and the USSR and for a long time remained exclusively in their hands.

Until the 1980s, this technology was a way to monitor the whole world, to the benefit of some. Space observation seemed to be a perfect control system, since the monitored states did not know the timing or the precision of the surveillance, and thus could not avoid it. Beyond its intelligence role, it had become a central instrument for the two superpowers to control information and allowed for various kinds of political pressure to be brought to bear against the countries observed.

Today, this technology is becoming freely available and, theoretically, the current system already allows for the observation of everyone by everyone. But space observation is not yet completely commonplace and has not yet entered mass use. The operators expect market development in the years to come.

During this transition phase, high resolution imagery is an especially sensitive subject for the American intelligence and military services. This attitude undoubtedly reveals a significant disinclination to abandon their control of this instrument of power. Officially, the American leaders cite the US security risks that could arise from broadcasting space imagery.

The United States is vitally concerned about the growing dissemination of space imagery. Considering itself the major power in the post-cold war world, it is trying to maintain stability and is monitoring, among other things, the dissemination of technologies that could affect it negatively. In the framework of a redefinition of the US defense policy, the Bush administration is intensely interested in this question.

Additionally, the United States played a key role both in conquering space and in developing civilian and military information technologies. It now has uncontested industrial power and technological advantage in the aeronautics and space sector. Controlling the dissemination of the imagery is important for security reasons, but also for the maintenance of the dominance of US industries in this sector.

After analyzing the potential risks and listing the existing commercial systems, the various possibilities for control developed by the US will be evaluated.

1- Risks of Marketing High Resolution Images

There are different kinds of direct sensor inputs for space observation satellites. Panchromatic sensors obtain images that resemble true black and white photographs. They are generally more precise in terms of ground resolution. Multispectral or hyperspectral sensors film the Earth in different spectral bands, thus revealing indications of the nature of the ground in different colors (cement or asphalt, vegetation, minerals, water tables, etc.). Sensors working in the thermal infrared band more closely monitor heat sources, allowing, for example, an indication of missiles taking off. Finally, radar sensors can see at night or through clouds, and this function is very useful in monitoring regions with an oceanic climate.

These images, analyzed by a photo interpreter using complex software, provide concrete information to military and political leaders and to members of civilian society. They are used for different purposes.

For about fifteen years, a number of very specific studies on what could happen in terms of international affairs as a result of the acquisition and interpretation of commercial space imagery were done at research institutes, NGOs or government agencies.

In view of the dissemination of this new source of information, starting in the 1980s, it was of interest to see what the non-state players could utilize in their activities, most often connected to disarmament issues. The studies done address such issues as the description of military installations in countries not sharing information, the functioning of confidence- and security-building measures in a given area, or compliance with commitments in disarmament treaties.

The authors used the first available images, with very low resolution, then used more and more precise resolutions offered on the market.

One of the first research projects done on the basis of commercial imagery provided a rather complete view of Soviet military and nuclear facilities on the Kola peninsula that had until then remained unknown to the public. This study, conducted in 1987 by a

Norwegian institute, is innovative. It is supported by low resolution Landsat images, and by the first Spot images available (Spot 1, between 10 and 20 meters of resolution).[8]

The numbers of this kind of project snowballed, showing the ever greater usefulness, with increasing image resolution, of commercial satellite imagery for security purposes.[9] For example, a study was done in 1996 on the Indian nuclear testing site at Rajasthan. It confirmed the usefulness of commercial space imagery for the verification, outside of any official national or international structure, of compliance with the nuclear test ban treaty.[10]

Official US agencies also financed this kind of research. In 1999, at Sandia National Laboratory, a study was conducted about the possibility of running a security system from the South China Sea, from Indian satellite IRS-1C images, with a resolution of 5 meters in panchromatic mode.[11]

But other players have also been able to use space imagery, this time for purposes perceived as hostile or at least problematic by the United States.

From the US perspective, using this source of information for directly aggressive purposes would be an indication that terrorist groups or States were pursuing goals openly opposed to western interests. It has also been noted that players such as the press and NGOs have made much use of space imagery. The publication of information derived by the latter from space imagery could, to a certain extent, be destabilizing for the Washington authorities.

a- A Potential Danger for United States Security

For the United States, the players who could use satellite images for directly military purposes fall into two categories:

- Enemy states, whether known as *rogue states*[12] or as *countries of concern.* Among the latter[13], China seemed to be especially prominent during the first months of the second Bush administration. As for Russia, “it is not an enemy, but it could be a threat,” said President Bush ambiguously;[14]

- Non-state players such as terrorist organizations obviously took priority among American concerns after September 2001.

One of these states or organizations could use satellite imagery to locate targets in an enemy country during the preparation phase of a military attack.

It is probable that the Iraqi military bought Spot images with a resolution of 10 to 20 meters to prepare bomb attacks and to evaluate the results during the war against Iran in the 1980s.[15] It is also possible that they used images from the same source to prepare the Kuwait invasion in the summer of 1990.

The more precise the available images, the greater their value in terms of military intelligence. The most precise imagery now available on the commercial market has a resolution of one or two meters. It is made by the American system Ikonos, the Russian Spin-2 and the Israeli Eros 1A. The US satellite QuickBird 2, which was launched in the autumn of 2001, was to offer images with a resolution of 70 cm as of the spring of 2002. In December 2000, Space Imaging obtained a license from the Commerce Department to manufacture a satellite with a panchromatic observation sensor with a resolution of 50 cm. The company announced the launch of this satellite in 2004.

Space imagery can be integrated into a pre-existing aggression project initiated by a government or an organization.

Alternatively, it can also, by itself, lead to an outbreak of hostilities. The images can disclose to a government the military vulnerabilities of an enemy state and make the option of a surprise attack tempting. They can also signal troop movements or other military actions in a neighboring country. These, wrongly interpreted as threatening by a state, would lead to a preemptive strike, which may not have taken place otherwise. The imagery could be the direct cause of military operations.

Countries located in very unstable regions fear this possibility and it is this argument that the Israeli government is using to try to slow down the sale of satellite images in its territory. Neighboring states with poor relations, such as India and Pakistan, are also suspicious of the sale of images from their territory. India, which has a high resolution

commercial observation system (IRS system), has developed a fairly restrictive sales policy.

Table 1

Resolutions Needed to Observe Military Targets

In light gray, what can be conserved using imagery with a one-meter resolution (currently available)?
In dark gray, what else can be seen using imagery with 50 cm of resolution (license obtained in December 2000, operational 2004?)?

Target	Detection	Identificatior	Precise identification	Description	Technical analysis
Troops	6 m.	2 m.	1.20 m.	30 cm.	15 cm.
Vehicles	1.50 m.	60 cm.	30 cm.	6 cm.	4.5 cm.
Airplanes	4.50 m.	1.50 m.	1 m.	15 cm.	4.5 cm.
Airports	6 m.	4.50 m.	3 m.	30 cm.	15 cm.
Nuclear arms components	2.50 m.	1.50 m.	30 cm.	3 cm.	1.5 cm.
Missile bases (surface-to-surface and surface-to-air)	3 m.	1.50 m.	60 cm.	30 cm.	4.5 cm.
Rockets and artillery	1 m.	60 cm.	15 cm.	5 cm.	4.5 cm.
Surface vessels	7.50-15 m.	4.50 m.	60 cm.	30 cm.	4.5 cm.
Surfaced submarines	7.50-30 m.	4.50-6 m.	1.50 m.	1 m.	3 cm.
Roads	6-9 m.	6 m.	1.80 m.	60 cm.	40 cm.
Bridges	6 m.	4.50 m.	1.50 m.	1 m.	30 cm.
Radar facilities	3 m.	1 m.	30 cm.	15 cm.	1.5 cm.
Radio equipment	3 m.	1.50 m.	30 cm.	15 cm.	1.5 cm.
Command and control centers	3 m.	1.50 m.	1 m.	15 cm.	9 cm.
Equipment storage	1.50-3 m.	60 cm.	30 cm.	3 cm.	3 cm.
Minefields	3-9 m.	6 m.	1 m.	3 cm.	--
Urban areas	60 m.	30 m.	3 m.	3 m.	75 cm.
Coasts, landing beaches	15-30m.	4.50 m.	3 m.	1.50 m.	15 cm
Ports	30 m.	15 m.	6 m.	3 m.	30 cm.
Railroad facilities	15-30 m.	15 m.	6 m.	1.50 m.	40 cm.
Terrain	--	90 m.	4.50 m.	1.50 m.	75 cm.

Source: Ann Florini, "The Opening Skies: Third Party Imaging Satellites and U.S. Security," *International Security*, vol. 13, no 2, autumn 1988, p.98.
Definitions:
Detection: location of a kind of component, of objects or of activities of military interest.
Identification: determination of a certain type of target.
Precise Identification: distinction among several kinds of targets within the same category of targets.
Description: size/dimension, configuration/organization, construction of components, itemization of units, etc.
Technical Analysis: detailed analysis of specific components.
Note: The sources do not specify whether the resolution is expressed in pixels or in points.

A terrorist organization could also use commercial images to learn exactly where the troops of a target state are and how their facilities (embassies, military bases, etc.) are laid out. A terrorist attack on the model of the attack of the American vessel USS Cole in the port of Aden in October 2000 could be organized using space imagery.

The events of September 2001 showed the unthinkable reality of the terrorist threat to the United States. Although it is not certain that space imagery was used by the organizers of the attacks on New York and Washington, it is clear that the US authorities would like to have even better control in the future over use of imagery.

b- Loss of Control over Information

Commercial imagery could also be put to destabilizing use by a government beyond the military or terrorist context. For many years US leaders have seen such images disseminated to general information sources. In fact, newspapers television and NGOs can now buy their own images and present their own interpretation of issues and events. The examples known as of today involve the western media or NGOs in particular, which have been able to launch a more or less direct challenge to the US government.

The press began to use space images in 1980 to support information provided. Four days after the Chernobyl nuclear plant accident in April 1986, the US television network ABC showed Landsat images of the area, soon replaced by Spot images, which are more precise. Not only could the Soviet government not deny the facts, but the western governments could not either.

Some newspapers tried to use commercial imagery during the Gulf War in 1991, presenting images of oil wells on fire at the end of the conflict. They could use Meteosat images, with a very coarse resolution (around several kilometers). The much better Landsat 4 images were not accessible to the media during that time. Landsat 4 has an infrared thermal sensor, which picks up heat sources, with a resolution of approximately 120 meters.[16]

Since then, the precision of commercial images has improved a great deal and the consequences of this evolution have begun to be felt. Ikonos, the satellite of the US

company Space Imaging, takes images with a resolution of one meter in panchromatic mode. In March 2000, the *New York Times* published two Ikonos images of the city of Grozny,[17] one dating from December 16, 1999 showing the city intact, and the other dated March 16, 2000 showing the city destroyed. During the Russian army offensive, neither journalists not the humanitarian organizations were authorized by Russian authorities to enter the area. The US State Department, for its part, said it would not intervene in this Russian domestic issue.

These satellites images were used during a US Senate hearing, which was unprecedented.[18] Faced with questions from the committee members, the US government was forced to adopt stronger language with the Russian authorities.

This is a battle over the power of information that some NGOs want to initiate. Parallel to the media's action, NGOs also used space imagery to produce their own analyses and to make them public.

The Federation of American Scientists (FAS), an American pacifist organization, led an initiative between 1996 and 2000 called *Public Eye*. Its objective was to show certain contradictions in the US government's foreign policy and security positions, based on a study of satellite images of specific sites. Images and analyses were then published in the press and on the FAS web site.[19] The year 2000 saw an especially large number of revelations, mainly based on images taken by the US commercial satellite Ikonos:

1) In January 2000, FAS presented the image of a ballistic missile test site in North Korea, concluding that its infrastructures are much more primitive than had been thought by the US proliferation experts;

2) In March 2000, FAS presented the image of a nuclear missile site in Pakistan, showing, on the contrary, that these facilities were much more developed than had been thought. This revelation coincided with a visit by President Clinton to India and Pakistan and required that he answer questions from the press about non-proliferation on the Indian subcontinent;[20]

3) In May 2000, images of civilian and military air facilities along the coast in the south of China allowed FAS to confirm that the Chinese defenses against Taiwan were not as powerful as the US government indicated.[21] Undoubtedly for FAS it was a matter

of presenting different views at the time the US Congress was voting on the law on resuming trade with China. John Pike, in charge of the *Public Eye* project at FAS, had conducted a fairly technical and very detailed study using several types of satellite images: Images taken by the US military systems in the nineteen sixties and later declassified, Russian images taken in the 1990s, and Ikonos images;

4) In August 2000, a study on the Israeli nuclear reactor Dimona was finally conducted. For the first time, it provided public proof of the existence of Israeli nuclear arms.[22] The policy of denial in Israel and the US since the nineteen seventies is no longer possible.

The quality of the interpretations of these images given by FAS is generally highly debated by other space observation experts. This organization is not an intelligence agency and does not have a rich, multisource network to help it interpret the images it can obtain.

But the goal of the *Public Eye* project, according to John Pike, is just to show the powers that be that they have no exclusive right to know and that they have lost some of their power. This is a challenge through possession of information. The reactions of the government authorities can continue to be watched with interest in the years to come; the *Public Eye* initiative will continue with a new organization, *GlobalSecurity.Com*, founded by John Pike upon his departure from FAS in the fall of 2000.

The upheavals tied to commercial space imagery could be considered a new phase in the public access to information. Similar reactions occurred after the birth of the mass press in the nineteenth century, of photography and cinema around 1900, and of electronic communications in the second half of the twentieth century.

Imagery, a new information tool available to the media, allows them to put a great deal of pressure on the government, making it react quickly, probably in line with public opinion, which can rarely be reconciled with the discretion and the slow pace of diplomatic efforts. This effect is especially felt in the United States, where the right to information is guaranteed by the first amendment to the Constitution and where the media traditionally play a very important role in public life. Information there is even more of an instrument of power than it is elsewhere.

When there is a regional crisis, for example, the presentation of information by the press that is contradictory to the government's information could hinder the government's actions. The United States would have a very high political price to pay for committing troops in battle when public opinion opposed it. Conversely, it could be pushed into an intervention they never wanted to start with.

In the fall of 2001, it appears that the US government was able to learn a lesson from the publication of images of Grozny or the FAS campaign. In order to manage its military operations well in Afghanistan, the government did not want to run the risk of unfavorable images being published by the press, even though it is known that the press and the media themselves limit their criticism during difficult international situations.[23] The Department of Defense bought exclusive rights to all of the images of Afghanistan produced by Space Imaging, the only company currently producing high resolution imagery. Thus, no other players could obtain any of them.

c- Problems Using Imagery

The risks in disseminating space imagery to hostile or destabilizing players are still limited by problems obtaining and interpreting the images, and the need to integrate the information received into more extensive systems.

Whereas the media and NGOs had few problems so far when they wanted to acquire a satellite image, the states and organizations considered hostile by the United States do not necessarily have access to this imagery.

Few countries have deployed their own observation systems to date, but some projects have been announced. China is developing a radar satellite project, and, in cooperation with Brazil, a series of four Spot-type satellites is being deployed. Long delays should be expected for such high tech projects, but some of these countries will undoubtedly eventually deploy operational systems. Pakistan launched a multispectral satellite with a resolution of 250 meters on December 10th, 2001. India deployed one of the most precise systems to date, which has a resolution of 5 meters in panchromatic mode and 23 meters in multispectral mode. In October 2001 it launched an experimental TES satellite (Technology Experiment Satellite) that tests a sensor with a resolution of one

meter. Taiwan has just bought an observation satellite from Astrium allowing for a resolution of 2 meters. This Rocsat satellite will be launched in 2002 or 2003.

The greatest number of “at risk” players identified by the United States will not have independent space observation systems in the foreseeable future. If North Korea, Iraq and other rogue states or terrorist organizations had the enormous financial and technological resources needed to manufacture a system, they still would need access to a launch vehicle, so this prospect seems relatively unrealistic.

Another scenario assumes they could hijack an operational observation satellite. They would need to take control of the satellite from the ground, manage and decode communications, probably by taking possession of a ground control station.[24]

Alternatively, these hostile players could buy imagery from a commercial operator. American companies cannot sell imagery to persons listed as dangerous by the State Department. They will therefore need to use a front man or find an operator in a neutral or friendly country. This is the most credible scenario at present.

After the image is obtained, it should be analyzed. Satellite imagery interpretation is an extremely difficult technology and numerous interpretation errors are made. Photo interpreters should receive extensive training in reading images. It is currently thought that if the type of radar or optic sensor evolves, even toward greater precision, or if the type of object sought is no longer the same, the best analysts make glaring mistakes. Ongoing training is essential. Next, it is essential to be able to correlate information deduced from the images with intelligence coming from other sources.

It is hard to know whether the states and organizations acknowledged as hostile by the United States have competent photo interpreters. It can be said with more certainty that journalists are rarely trained in this technology. Even if they use a photo interpreter, they do not have the ability to check whether the information provided by the images is plausible. Indeed, in recent years a certain number of mistakes have been noted in the explanations provided by the media about satellite images, some of which appear on page one.

In May 1998, for example, *Newsweek* magazine published a satellite image of the Indian nuclear test site north of the state of Rajasthan, where India had just conducted five

nuclear tests. The image was presented as dating from a week before the tests and the various components present in the photograph were itemized. The magazine later admitted that the photograph had been taken five years earlier and that none of the explanations provided were accurate. The excavation in which the tests were thought to have been done was really just a cattle yard.[25]

The non-governmental players should gain credibility over the long term so that public opinion can rely on the interpretations of space imagery they present. Journalistic ethics require, for example, that they verify all information from two different sources. This rule could be expanded to include satellite information. This would mean that each image would be presented to two different photo analysts to confirm the nature of the components contained in the image.

Finally, for players pursuing precise military or terrorist objectives, obtaining and analyzing the image will not be enough. It is necessary to integrate the space information into a more extensive system.[26] To launch a missile, for example, the weapon and the vector must be known, of course, to build a flight plan. The information on the target obtained from the satellite image must be integrated into a navigation system. The action itself will involve elaborate telecommunications networks. A military operation assumes the presence and control of various complex components, which are not within everyone's reach.

The recent attacks on the United States show that the resourcefulness of the terrorist networks is unlimited. They can bypass high tech resources–missiles, for example–and use unexpected but equally effective resources, such as airliners. In this context, and from the perspective of the United States, space imagery is not a crucial security issue, but its dissemination should remain closely monitored.

2- Emergence of a Commercial Market

a- Operational Systems in 2002

The expansion of commercial observation systems has been taking place since the 1980s. During the 1960s, space observation technology was strictly classified and reserved for the military or the highest Soviet and American political leaders. Civilian access to satellite imagery began in 1972, when NASA put Landsat 1, a low resolution observation satellite (approximately 75 meters) into orbit. The Landsat images were intended for research on the Earth and oceans by the global scientific community. Throughout a first period, these images remained free of charge. They were not intended for commercial use, but for research. Some meteorological satellites, with even lower resolution (several kilometers), also started to operate at this time.

The question of public access to imagery that could potentially be used for purposes related to security began to arise in 1986, when France launched its first space observation satellite, Spot. Programmed for specifically commercial use, its resolution is 10 meters in panchromatic mode and 20 meters in multispectral mode (for the currently operational Spot 1, 2 and 4). In 1990-1991, the Gulf War attracted attention to the specific possibilities of these civilian systems. The use of Spot images by the Pentagon to create precise maps of the Gulf region elicited a good deal of publicity.

Several commercial operators and systems followed. After the fall of the USSR in 1991, the company Sovinformsputnik obtained the right to sell images from the KVR intelligence system, downgrading it to a resolution of two meters. In 1995, the Indian system IRS became operational. The IRS images were firmly presented as the equivalent of Spot images, but less expensive. The companies are in a highly competitive commercial situation.

American companies wanted to be able to enter this market and, in 1994, the Clinton administration adopted the *Presidential Decision Directive 23* (PPD 23), authorizing the marketing of images and observation systems with a resolution comparable to that available on the global market. Several consortia of American companies quickly filed

applications for operating licenses. Space Imaging has had an operational satellite with a resolution of one meter since the end of 1999. In September 2001, DigitalGlobe (formerly EarthWatch) launched an observation satellite with a resolution of 70 cm that will be operational in the spring of 2002. After losing OrbView 4 in the fall of 2001, OrbImage should soon be launching the satellite OrbView 3.

In the summer of 2000, the Russian company Sovinformsputnik responded by decreasing the resolution of some of its images to one meter. It has had an operational system with a resolution of two meters, and an archive of very high precision images since 1992. Until now it was required to downgrade these archive images to two meters to sell them. To compete with the Space Imaging system, it can now downgrade them to only one meter of resolution.[27] It does not seem that the Russian company currently has a sensor with resolution of one meter to fill recent image orders.

In December 2000, the company ImageSat International,[28] an Israeli-American consortium, launched its first satellite, Eros 1A, with images providing a resolution of 1.8 meters in panchromatic mode. On the same date, Space Imaging received the license needed to launch and operate a sensor with a resolution of 50 centimeters.[29]

The evolution towards increasingly higher commercial resolutions seems to be continuing.

Table 2
Commercial Systems with a Resolution Less than or Equal to 10 meters and Operational in the Spring of 2002

System	*Operational*	*Resolution*	*Operator (country)*
Ikonos-2	End of 1999	**Panchro.: 1m** MS: 4m	Space Imaging (United States)
IRS-1C et IRS-1D	1995 1997	Panchro.: 5m MS: 23.5m, 70.5m, 188m	Indian Remote Sensing Agency (India)
Radarsat	1995	Microwave: 8-100m	Canadian Space Agency (Canada)
Kometa	1981 (public: 1992)	**Panchro.: 1-2 (?)**, 10	Sovinformsputnik (Russia)
Resurs-F	1974 (public: 1992)	MS: 4-7, 15-30	Sovinformsputnik (Russia)
Spot 1, 2 and 4	1986 1998	Panchro.: 10m MS: 20m	Spot Image (France)
Eros 1A	December 2000	**Panchro.: 1.8m**	ImageSat International (Israel and United States)
QuickBird 2	October 2001 (operational February 2002)	**Panchr: 70cm** MS: 2.8 m.	DigitalGlobe (United States)

Notes: in bold, the finest resolutions available today (panchromatic mode)
Panchro: panchromatic (black and white)
MS: multispectral (spectral bands, color recreated)

Table 3
Launches Scheduled for 2002-2004

System	*Launch Date*	*Resolution*	*Operator (country)*
IRS-P5	2002	Panchro for cartography	ISRO (India)
OrbView 3	2002?	Panchro: 4 MS: 10	OrbImage (United States)
Spot	1st quarter 2002	Panchro: 2.5 m. MS: 10 m.	Spot Image (France)
Rocsat 2	mid-2002 or 2003	Panchro: 2 meters	NSPO (Taiwan)
Alos	2004	Panchro 2.5 meters IR visible and near SAR	(Japan)

Notes: IR for infrared
* The resolution of hyperspectral images provided to its private clients cannot exceed 20 meters.

b- Problems Encountered by Operators

But the venture remains difficult for entrepreneurs, first for technical reasons and then because the market does not yet show strong revenues.

Space conquest technology remains hard to control. It has been common for imagery companies to lose a satellite during launch, probably because they had chosen unreliable launcher systems. Before launching Ikonos 2 at the end of 1999, Space Imaging started by losing Ikonos 1 at the beginning of 1999.

DigitalGlobe successfully launched the satellite QuickBird 2 in October 2001. But this American company lost its first two planned satellites during launch: EarlyBird 1 in 1997 and QuickBird 1 in November 2000. OrbImage lost its satellite OrbView 4 in September 2001.

At the beginning of the 1990s, market research was based on the expectation of a supply of 8 to 12 high resolution satellites, operational in 2001. Currently there are only three operational systems offering images with a resolution of less than two meters (Ikonos, Kometa and Eros 1A). QuickBird 2 will be operational sometime in the spring of 2002. The technical problems have been much more substantial than planned, leading to a slippage in all of the projects, all delayed by at least 5 years.

The second problem facing the commercial companies is the extent of investments required.

Table 4
Cost of Several Current High Resolution System Projects

Company	***Satellites***	***Planned Investment***
Space Imaging	Ikonos 1and 2	750 M$
OrbImage	OrbView 3 and 4	250 M$
EarthWatch	QuickBird 1 and 2	186 M$
ImageSat International	Eros 1A, 1B, 1C	300 M$

Source: *The Economist*, May 6, 2000, p.72.

For the US companies Space Imaging, OrbImage and DigitalGlobe and for the Israeli company with American participation ImageSat International, the average investment per satellite is approximately 160 million dollars, with the understanding that constellations of two or three satellites are most common.

The global commercial satellite imagery market has not yet fulfilled its promise. At the beginning of the 1990s, several analyses projected substantial, rapid profitability of investments.[30] But the annual revenues from the space observation market are currently estimated at 200 million dollars.[31] The projects are not at all profitable at this point!

The slow development of this market is due in part to the intense competition in air imagery. For 2001, commercial revenues from air observation are estimated at 2.85 billion dollars compared to under 200 million for space imagery. Commercial air observation is older than space imagery. It has had time to become habitual with a broad clientele and to perfect a very satisfactory product. Air imagery is more flexible to use, that is, more quickly delivered. The finished products are less expensive because the production costs for an image, even the marginal costs, are much lower.[32]

The quality of the products is also excellent. Airplanes fly much lower than satellites. Although this constitutes a geographic limitation to their operating radius and prevents them from quickly imaging vast zones (because their orbit track is very narrow), their resolution is quite fine, between 10 and 15 cm or 1-2 meters.

Having long established productive relationships with a stable clientele, the manufacturers in this sector were able to adapt their products to demand and are relatively advanced in processing the imagery. The processing software and the

integration of air data with information from other sources are constantly being improved. Ron Stearns, aerospace and defense analyst with Frost & Sullivan, estimates that revenues from the air observation market should double between 2001 and 2005 (from 2.85 to 4.1 billion dollars), not so much because the demand is going to increase, but more because the quality and prices for the products available should be much higher.

The estimated growth rates for the air observation market vary from 7.8 and 11% a year between 1998 and 2005. If the growth rate is indeed less than that projected for the space imagery market, the gross revenues from air imagery will be ten times greater than those from space imagery in 2005.

Table 5
Estimated Evolution of Global Space and Air Observation Markets

	Air Imagery Market[33]		***Space Imagery Market***	
	Revenue in M$	***% Market growth***	***Revenue in M$***	***% Market growth***
1998	2170		139.3	16.1
1999	2410	11	153.6	10.3
2000	2620	8.7	172.9	12.5
2001	**2850**	**8.7**	**197.1**	14.0
2002	3190	8.4	231.1	17.3
22003	3510	10	275.1	19.0
2004	3830	9	343.8	25.0
2005	**4130**	**7.8**	**419.5**	22.0

In the absence of a real market for space imagery, the private companies cannot develop with their own resources. The satellites launched by the French company Spot Image were financed with public funds (French, Belgian and Swedish). To date, the company has been content with seeking profitability with respect to the operational costs, not reimbursement of front-end investments. But the private companies cannot function on a sustainable basis without reimbursing these investments. They are counting on strong growth in demand.

c- Conditions for Loosening the Market

Only the emergence of mass demand would be capable of ensuring the profitability of the existing or planned commercial satellite systems.

Until now, imagery buyers have remained mainly the institutional clients, such as military clients for security uses, but also environmental planning, agricultural and fishing authorities.

In the United States, local administrations such as counties are becoming accustomed to regular mapping of their territory in order to follow environmental and urban developments.[34] Spot Image has already established space mapping of eighteen US states and has orders to image the other states. The European Union is buying imagery to monitor issues related to the common agricultural policy.

It would appear that in addition to these traditional clients, there are beginning to be private and industrial clients as well. These latter parties would have realized the potential of space imagery to meet specific needs. Mobile phone companies need up-to-date geographic information to decide to install telecommunication relay stations (Istar). Water or gas distribution companies can also use them to manage their pipeline networks (Vivendi), and petroleum companies wishing to cross vast desert areas with their pipelines can use such maps as well.

Companies selling chemical fertilizer can look for potential customer areas using multispectral imagery, which will show them soil composition and crop conditions.

More precise cartography could be useful for insurance companies wanting to verify that their clients properly met their obligations, such as clearing their property to prevent forest fires; and tax administrations would use the same images to assess the value of the property.

But imagery companies must also be able to count on the renewal of orders over a number of years. Will clients likely to order imagery in enormous quantities need to update their inventory of maps every year? For telephone companies, for example, the ground to be covered with communication relays will always be the same. But they will need to update their satellite data inventory to take construction in the zone into

account. Similarly, it is essential to renew the images when monitoring urban or agricultural development.

But the interest of public and private customers in imagery in general cannot really open up until the images and their byproducts can make themselves useful, even essential. The companies need to be able to present easily read images, so the information provided to the client is immediately comprehensible. There needs to be added value given to the raw images, using more efficient processing software. Investing in these services has a dual advantage for the companies since, in addition to attracting private clients, it is also the most profitable segment of the market. It is in processing and interpretation that the companies can gain significant benefits. The raw images are sold at an artificial price in relation to their production cost. The companies keep this price low for marketing reasons. On the other hand, the prices for extra services could correspond to their real cost and include a significant margin.

Up to now, companies have neglected these investments. At OrbImage, for example, the two main clients as of now are the US government clients (representing 7 to 8 million dollars in orders for geodetic products each year) and foreign clients, mainly institutional. These two kinds of clients are not interested in imagery processing by OrbImage.[35] They have their own software and their own photo interpreters.[36]

Private clients are in third place at OrbImage. This kind of client does not know how to interpret the imagery alone. But rather than developing this service internally, OrbImage sends its clients to partner companies.

US imagery companies depend on government clients and are now taking their time developing processing capacities that could attract civilian private clients. It is a vicious circle: The companies do not develop this sphere of activity because the volume of sales does not justify it, but the clients from the private sector will never come until they develop an adequate supply of value added products.

Operators not in the public domain, such as Space Imaging, do not provide figures for their forecasts and results. Outside analysts do not agree on the observation satellite market outlook. They themselves do not make any forecasts for development of the market share between space and air imagery, the emergence of new imagery clients,

the number of operational satellites as of a certain date, or even the price for future proposed products.

This last point is especially hard to determine. Even if companies release price lists, clients may negotiate deeply reduced prices, depending on the size and regularity of their purchases, the kind of area being imaged, and the system for obtaining the images (purchase of the images from the company or a concession holder, creation of a direct reception station for the client). The price reductions can go up to 40% of the list price, for Space Imaging.

It is also hard to compare the prices for images proposed by the various companies, because the products are not equivalent. The resolution and size of the scenes are not the same, and the types and levels of processing proposed are not the same.

Considering the disappointments following the enthusiastic forecasts at the beginning of the 1990s, analyses tend to be more cautious today. Although Tom Watts of Merrill Lynch was able to think that the revenues from imagery sales would reach one billion dollars in 2005, Ron Stearns of Frost and Sullivan remains more conservative, with an estimate of 420 million dollars for the same date.

Table 6
Commercial Observation Revenues: Optimistic but Increasingly Conservative Forecasts

	Merrill Lynch April 1998		**Frost & Sullivan 1998**		**Frost & Sullivan 2000**	
	Revenue in M$	% Market growth	Revenue in M$	% Market growth	Revenue in M$	% Market growth
1998	140	16.7	140	16.7	139.3	16.1
1999	188.44	34.6	180.4	28.6	153.6	10.3
2000	253.6	34.6	231.5	28.6	172.9	12.5
2001	**341.4**	34.6	**297.7**	28.6	**197.1**	14.0
2002	459.5	34.6	382.9	28.6	231.1	17.3
2003	618.5	34.6	492.4	28.6	275.1	19.0
2004	832.5	34.6	698	41.7	343.8	25.0
2005	**1120.6**	34.6			**419.5**	22.0
2006	1508.3	34.6				

The path to be followed seems clear for companies wishing to develop beyond government image contracts. They have to create a need for imagery among industrial clients, the only ones who might buy large quantities of images. To do this, it is necessary to develop software that is capable of transforming the raw data into information that is easily used by non-specialists.

This step is not necessarily incompatible with meeting US government security requirements. It is likely that the areas of interest to future private clients will not be those being looked at by the military and the intelligence agencies. Federal authorities may limit access to images in war zones without affecting the commercial activities of imagery companies.

But as things stand now, it is probable that the imagery companies will continue to exist thanks to orders from federal agencies, without looking to extend their market reach.

3- US Government Options For the Control of Imagery

In the summer of 2001, it was noticed that the US government had set up a fairly extensive group of mechanisms for the control of imagery dissemination, but that these mechanisms had not yet faced reality. A truly large test remained to be seen. This happened with the unexpected violence against the United States.

The administration reacted by adapting the planned control mechanisms to the circumstances. It also considered imagery control and it is possible that it will reshape the entire system in the coming months.

The control resources available to the US government should be able to serve the whole range of American reactions in international relations, from diplomacy to direct confrontation. Certain resources, such as shutter control, are a legal constraint and can only be applied to national enterprises. Military resources, such as anti-satellite weapons, would be aimed at the systems of enemy countries. Beyond these coercive resources, the cooperation of the federal authorities with domestic companies and a dialogue with foreign companies are the first recourse, and probably the most effective.

In the first place, these control resources should be able to prevent the photographing of certain geographic areas or the broadcast of images gathered. But imagery companies may also broadcast archive images. Although the tactical utility of the images is generally linked to their timeliness, older images can also provide important information in some cases. Control resources also need to address this particular risk.

Control of US Imagery

The US government can control the sale of imagery produced by domestic companies in two ways. It can exercise the law against them, which includes a sales restriction system for security reasons, and it can develop a less aggressive system of agreements and cooperation.

a- The Strict Operating License Environment

Presidential Decision Directive 23 (PDD-23) dated March 10, 1994, authorizing the marketing of high resolution imagery, sets the boundaries for US regulatory activity.

The license to manufacture observation satellites is issued by the Commerce Department, and more specifically by the National Oceanic and Atmospheric Administration (NOAA). Before issuing a ruling, NOAA hears the opinion of the State Department's Bureau of Political-Military Affairs and of the Assistant Secretary of Defense (Command, Control, Communications, and Intelligence) (ASD/C3I). A MOU dated February 2000 added the Department of the Interior (in charge of environment issues) and the Intelligence community to this list. Five federal authorities are thus involved in the decision-making process.

The maximum resolution authorized for the images is not stated in the text of 1994. The PDD-23 only says that the systems will offer competitive resolution compared to other systems existing on the global market. With the licensing for the next Space Imaging satellite last December, this official limit is changing from one meter to 50 centimeters.

When it receives its license, the company agrees to comply with commercial embargoes imposed by the United States or the United Nations. The country affected by this action cannot buy images from the company.

Each license may also include specific restrictions. The license given to OrbImage to launch the OrbView 4 satellite (the launch of which in September 2001 failed) provided that its hyperspectral images with a resolution of 8 meters would be reserved for US government clients. The other clients had to accept images lowered to a resolution of 20 meters. However, the company had negotiated the right to sell byproducts of the initial products at high resolution.[37]

The recent license issued to Space Imaging provides an additional security measure, in the form of a mandatory delivery time of 24 hours, which will apply to all future buyers of 50 cm images. About 22 hours are needed between the time the image is taken by the Ikonos satellite and the final product delivery to the client. Acceptance, processing,

interpretation and sending of the images could be shortened in the future, but for now, the security time imposed by the administration is not really a hardship.[38] At this point, the company is not planning to award contracts for the direct acceptance of images by the clients.

Although this has not yet happened, the US observation systems could also be sold on a turnkey basis to foreign clients. The orders will then be examined on a case by case basis by the State Department's Bureau of Political-Military Affairs. All encryption software must be approved and monitored by the US government.

Other permanent or contingency conditions also apply.

A Specific Policy Towards Israel

Because of the US commitments to the security of Israel, it was possible for the leaders of Israel to get a special sales restriction from the United States on images of their territory.

The amendment to the National Defense Authorization Act dated 1997, known as the Kyl-Bingaman amendment, prohibits US companies from gathering or selling images of Israeli territory if they are more detailed or precise than the space imagery generally available from foreign commercial sources.[39]

In the summer of 1998, the government determined that the images of Israel available at that time from non-American sources had a maximum resolution of two meters. American companies then received an order from the Commerce Department not to sell images of Israel with a resolution under two meters.

The statutory instrument of 1994 appears to authorize US companies only to follow the developments of the global market, awarding licenses for resolutions "already available commercially or with availability projected on the international market." But the Department of Commerce has already awarded two licenses projecting more precise resolutions than those already in existence.

In 1994, Sovinformsputnik was offering images with a resolution of two meters and this was the basis for the US administration's decision. Shortly afterwards, Space Imaging obtained a license to build a satellite with a resolution of one meter.

The Russian company responded and, since June 2000, has offered a similar resolution on its web site. The US Commerce Department has now awarded a license for 50 cm. It is likely that foreign companies will follow up on this new development if they can.

The United States itself thus seems to be initiating the evolution of imagery supply towards increasingly fine resolutions. This causes foreign companies to adapt their products and directly threatens the balance projected by the Kyl-Bingaman amendment.

The government and Congress should undoubtedly review the system of restricting sales of images from Israeli territory soon. They will need to choose between harmonizing US law with the resolutions available in the rest of the world, and the desire not to affect Israel's security adversely.

Shutter Control

During the ground phase of Operation Desert Storm in 1991, the coalition led by General Schwarzkopf operated the "Left Hook" to surprise the Iraqi army. This important action precipitated the defeat of Saddam Hussein's forces. It would never have been so successful if commercial satellite images had disclosed Allied troop movements in advance.

The presidential directive of 1994 took this kind of risk into consideration. It gives the Commerce Secretary the power to limit the operations of a commercial satellite, "either when the Defense Secretary believes the national security is at risk, or when the Secretary of State believes that international and/or foreign policy obligations could be compromised."[40]

This is what is called shutter control. The satellite operator must limit the shots over the territory in question or limit distribution of the images. What is more, communications between the satellite and its receiving stations must be accessible to the government. This procedure has never been invoked.[41]

Shutter control, as it has been known since 1994, has been the subject of criticism. By seeking to prevent hostile players from gaining access to the imagery, it also prevents the media from gaining access to this information. This undoubtedly serves a secondary purpose of the government, which does not want politically embarrassing images to be published. But the press depends on obtaining the images.

There are known, specific limits in American law to the freedom of expression of the press in times of crisis. According to the jurisprudence concerning the first amendment to the Constitution of 1788, a “clear and present danger” or “a serious and imminent threat to national security” must be proven for the government to be able to prevent the freedom of information. In some cases, the government can be taken to court; the courts then will decide on the reality of these risks.[42]

The restrictions contained in PDD-23, as they are set forth, are much more vague. The directive contains the following phrasing: “When foreign policies may be compromised,” which seems quite broad and does not necessarily correspond to a real danger to the country’s security. It could lead to abuses that are incompatible with the spirit of the first amendment.

Some journalists have publicly expressed their intention to take the government to court upon first application of shutter control, in order to have it reworded.[43]

Under these conditions, and facing a serious international crisis in the fall of 2001, the government preferred to find an alternative solution to shutter control.

b- The October 2001 Agreement

On October 7, 2001, the National Imagery and Mapping Agency (NIMA, the intelligence agency providing imagery and analysis to the US military and politicians) entered into an unexpected and innovative agreement with the US company Space Imaging.[44] Under this agreement, the Thornton (Colorado) company agrees to sell its images of Afghanistan only to the Pentagon. This exclusive agreement will cost the Department of Defense 1.9 million dollars a month. The images will be billed at 20 dollars per square

meter, and each order will cover at least 10,000 km^2. The agreement is renewed monthly.

In the fall of 2001, Space Imaging was the only company that could offer images with a resolution of one meter on the commercial market. When the satellite QuickBird 2 is operational, around February 2002, if circumstances warrant, a similar contract may be entered into with DigitalGlobe, the company operating it.

This agreement serves multiple purposes. First, there is no need to run the risk that a hostile player can obtain sensitive images of the war zone, however improbable the sale of images of Afghanistan to private parties seems now.

Above all, the agreement aims to prevent newspapers and television from obtaining the images. During normal times, Space Imaging does not hesitate to fill orders from newspapers and network television. The company was about to enter into a major contract to supply images to CNN at the time of the NIMA proposals.[45] If the media published images of destroyed villages or of lines of refugees, this would place the US government in a very delicate position regarding Arab, and even western, public opinion. The lesson from publication of the Groszny images in the *New York Times*, and from the Congressional inquiries they triggered, has not been forgotten.

Officially, the buy out contract should also serve more concrete purposes. The images will be used first by analysts and cartographers from NIMA. They may also allow the US military to show unclassified images to prepare for joint operations with allied soldiers. During the Gulf War, in 1990-1991, US images, all classified, could not be shown during military briefings, which caused problems in the Coalition.

Finally, the agreement provides massive financial aid to the company. When PDD-23 was adopted in 1994, helping US companies become significant in the commercial market was a strategic objective. In the Commercial Imagery Initiative of 1996, the National Reconnaissance Office (NRO, which builds military space observation systems) and NIMA agreed to pay 40 million dollars a year for satellite images from the private sector from 2001 to 2003, then to double this amount starting in 2004.[46] In fact, this level of expenditure was never reached: NRO was hostile to a measure that could diminish

the utility of its own observation systems. The NIMA analysts for their part needed time to get used to using commercial images.

US imagery companies, which have not learned how to develop a sufficient private clientele, are finding their livelihood in contracts received from federal authorities. The question was asked at the beginning of the George W. Bush administration whether companies should continue to receive aid in the form of orders for imagery. Circumstances provided an affirmative reply.

The connection between imagery companies and intelligence agencies is underscored by the new agreement.

But this connection between imagery companies and the intelligence community already existed during normal times. If the agreement of October 2001 shows the great creativity of the US secret services, this is expressed within a more global context of dialogue among the players involved.

Long-Term Dialogue

The commercial imagery companies are private companies and loudly proclaim their complete independence from federal authorities. But this independence seems at least partially fictitious. In normal times, there is a certain dialogue between the federal authorities and commercial companies to prevent the companies from selling sensitive imagery to parties fronting for a terrorist organization or a state with aggressive intent.

Space Imaging, the US company operating the Ikonos satellite, displays on its web site a list of all of the images ordered from it, without specifying the client. It is thus possible, for an outside observer, to follow the imagery orders and make assumptions regarding the party ordering the imagery. The US intelligence services can monitor orders to the company from its web site.

If the services deem it necessary, they could ask the company's management to give them information on the client who ordered an image. The creation of Space Imaging was conceived by, among others, leaders of the US intelligence community in the 1980s.[47] Jeffrey Harris, former director of NRO from1994 to 1996, was then president of

Space Imaging until 1999. The CEOs of several US imagery companies hold regular meetings with the NIMA and NRO directors. Even if, since 1999, the company's ranks have been filled more and more by people from the areas of marketing and sales, it has retained a definite sensitivity to security risks. The questions asked by former colleagues undoubtedly are answered by the founders of Space Imaging.

From this information, US agencies can conduct investigations into dubious clients and find out who may be hiding behind their identity. If a player considered as truly dangerous (that is, a state or organization hostile to the United States) is suspected of being the ultimate client for the image, it is imaginable that the company would be alerted and, under some pretext, the order would not be filled.

Perhaps there is a natural reaction among the company's teams to call the intelligence services immediately to ask them to verify who a client really is. This habit could exist outside of any rigid, regulated procedure.

The existence of informal work agreements between a private company of this kind and the US intelligence services is not public and would be hard to prove. The award of a license to build an observation satellite with a resolution of 50 cm proves in any event that good relations exist between the Denver company and the federal authorities. These good relations have just been reinforced by the new administration.

Control of Foreign Imagery

The US government does not have the legal authority to interrupt sales of imagery by foreign companies. It is working on developing control methods outside of the use of force, but is also working on developing military resources.

a- Non-Military Resources

The End of Technological Dependency

In the 1990s, the control of foreign satellite systems could rest on the fact that these systems most often used components manufactured in the United States. Because of the insufficiency of the industrial base (in Europe, for example) or supply problems (in the former USSR), no company could build an entire system at that time without using US components.[48]

This situation gave the United States extensive maneuvering room. The impossibility of importing a major part from the United States could prevent a foreign company from completing construction of a satellite. But the tightening of control on US exports since 1998 led foreign aeronautic and space companies to find alternative sources of supplies. Control through technological exports is now greatly reduced and the government can no longer take it into consideration.[49]

Diplomatic Channels

First, the United States can put diplomatic pressure on friendly governments to impose the equivalent of shutter control on their companies in the event of serious international crisis. These allied governments should agree easily if their political objectives agree with those of the United States. During the Gulf War, then during the events in Kosovo, Spot Image did not sell images of the Kuwait region to clients other than the French and US militaries.

The United States also wants to ensure the attitude of its allies in a preventive way, by exporting its model of shutter control. The US pressured Canada so that Ottawa would adopt a legislative provision covering the possibility of interrupting Radarsat imagery sales in times of crisis.[50]

But if a party hostile to the interests of the United States were to deploy a commercial system, it would undoubtedly refuse to bow to US diplomatic pressure. The United States could then be inclined to use direct military resources.

The most complicated situation would be that in which the satellite system broadcasting images posing a risk to the United States security was operated by an international consortium. Steve Cambone[51] proposes the example of a consortium of Israel, Australia and the USA.[52] The United States could not use force to impose its point of view on these friendly countries. They could adopt very complex attitudes in the event of crisis. They could also join together to oppose United States choices or they might not be in agreement with each other. The United States would then be forced to engage in a very delicate diplomatic struggle.

International Rules of Law

International law provides a certain legal framework for the activity of imagery companies. At the instigation of the United States, The United Nations General Assembly recognized the evolution of space observation towards a commercial function and adopted a significant text in 1987.

The current principle of international law provides that any country observed by a commercial system must have access to the images taken of its territory on a non-discriminatory basis, for the standard price and within a reasonable period of time.[53] Where remote observation is authorized by the 1967 Outer Space Treaty, the states observed must be able to learn what images are taken of their territory.

But the commercial interest of the companies involved includes respecting their clients, and the interpretation of the 1987 policy has remained fairly restrictive. If a government expressly requests it, a commercial observation company must disclose what portions of its territory was photographed and offer to sell the government these images at the normal rate. But the company is not required to disclose the names of the original buyers ordering the images.

Also, the companies themselves do not have to warn foreign countries about images taken of their territory. Many countries are not sufficiently familiar with this method of intelligence to contact the imagery company themselves.

No doubt it would be impossible at this point to require companies to warn the countries where satellite images have been ordered. The companies would not want to disclose the identity of their client, and it would be easy for them to remember that many countries do not yet have an administration that is clearly in charge of these matters for them to contact.

Space Imaging displays on its web site a list of the geographic coordinates of images taken by its Ikonos satellite and even displays a small downgraded version of the image.[54] So it can be seen, on this company's web site, that many images of South China have been ordered in recent years, including all of the civilian and military airports, the port facilities and military installations in general (these images were used by the Federation of American Scientists for its study of May 2000, but this group is not behind the initial order). It can be assumed that these images were bought by Taiwan, which wanted to keep up to date on Chinese military activities in the area. The Chinese authorities, if they visit this web site, can reach the same conclusions. The spirit of the policy of 1987 is being respected in this case.

The US company is in line with international law by making all the information accessible on its web site, without having to warn the leaders of the states involved.

From the point of view of the United States, it would be useful for this practice to expand gradually throughout the world. It would allow the US to follow foreign companies' activities easily. The evolution of the practice of companies in this domain is not complete.

Promote Market Domination by American Companies

From the provision of financial aid to US imagery companies, an indirect but effective impact is expected on the dissemination of foreign imagery.

Great discussion preceded the adoption of PDD-23 in 1994, and of the Commercial Imagery Initiative in 1996. The Clinton administration finally decided that US companies had to have a presence in the new commercial imagery market, which already included

foreign companies. What is more, it was necessary to ensure US domination of this market in order to be able to control the flow of trade.

In fact, if the market could be dominated by American companies, they would have the resources to develop a more competitive supply in terms of quality and speed of processing the information. An intense effort to develop the processing software could follow and the US companies would be in a position to develop and to impose on the rest of the world standard computer processing modes. They could then have a captive international clientele.

International competition would not necessarily disappear, but its market share would be reduced and the quality of their products would be surpassed by the US product. In the event of crisis, an interruption of activity by US companies would dry up the market. Foreign supply would not necessarily be able to meet the demand on it.

Despite their diversity, none of these peaceful means comes with an absolute guarantee for the US government. Development of military resources seems appropriate today.

b- Anti-Satellite Weapons Programs: Different Levels of Aggression

If the national security is at risk, the United States could finally end up using force to prevent dissemination of foreign imagery. The military resources first seek to interrupt the gathering of imagery by the space systems, but they could also prevent transmission of archive images.

The Department of Defense laboratories began research and development programs for anti-satellite weapons (ASAT) by the end of the 1950s, but without ever reaching deployment. The Eisenhower administration and subsequent administrations did not want to risk expanding into space the arms race with the Soviet Union.[55] Later, Congress was quite reticent when the Reagan administration wanted to conduct tests of the technologies developed.[56]

These programs were first aimed at the capabilities of the Soviet Union. Within the current strategic context, they would be deployed against all of the new enemies of the United States.

Both imagined actions technologies already developed and their deployment site (ground, orbit, etc.), all of the parameters remain quite diverse in a domain of the art of war that still remains to be invented. A typology of the various types of offensive actions considered by the Defense Department was made public.[57]

1) Disruption is a temporary dysfunction of the satellite system, such as, for example, the electronic jamming of communications (command and transfer of data) between the satellite and the ground station;
2) Denial is a temporary breakdown in the system, for example disabling the sensor;
3) Degradation consists of inflicting a permanent dysfunction on the system, such as, for example, the destruction of ground stations, which is very easy to accomplish with conventional resources;
4) Finally, destruction is the permanent breakdown, that is, the destruction of the satellite in orbit.

This typology classifies the possible actions in increasing order of the level of violence. If action is necessary, the Department of Defense should choose on the basis of political considerations. The degradation or destruction of systems would be a very aggressive signal, unthinkable outside of declared hostilities, and would create a serious precedent for military action in space. Using them would be significantly weighted with political meaning.

On the other hand, the disruption or interruption of systems is easier. Such actions can serve specific tactical interests in the course of a conflict and would not necessarily have political significance. In fact, they could be considered as accidental by the satellite operators: It frequently happens that a satellite experiences technical difficulties where it is impossible to determine the exact causes from Earth. These two forms of action, the use of which is more credible than the overly aggressive options, are being actively explored by Pentagon laboratories.

The various laboratories of the US military are pursuing R&D programs for anti-satellite weapons covering diverse, very innovative technologies. Chemical and kinetic interceptors and low-energy lasers are considered by the US Department of Defense to

be the easiest. Nuclear arms and radio frequency weapons are more complex and high-energy and particle ray lasers are the hardest to develop. The Air Force is working on an orbit laser system (SBL, or Space Based Laser) and, more recently, on a system to jam ground-based satellites (Space Control Technology); the Army is developing a ground-based satellite interceptor (KEAsat, or Kinetic Energy Asat); and a ground-based laser, named Miracl for Mid-Infrared Advanced Chemical Laser, was tested in 1997.[58]

It can be assumed that these programs will be reinforced in the future. On May 8, 2001, the Secretary of Defense Donald Rumsfeld announced his intentions regarding military space policy. Along the lines of the conclusions from the report he oversaw, in the fall of 2000, he emphasized the "inevitable expansion to space of acts of war"[59] and the need for the United States to prepare for it.

Some experts see in these projects the seed of an arms race in space, which it has been possible to be avoid so far.[60] They stress that although protection of US space stations should now be reinforced, the creation of aggressive systems is more debatable, since currently there are no adverse systems. The launch of these programs by the United States could trigger similar programs abroad, which would be completely contrary to American security interests.

Despite the criticisms this attitude has already received, the Department of Defense should see its defensive and offensive space programs considerably strengthened. But taking into account the war operations undertaken in the fall of 2001 and the priority given to the anti-missile defense system, it will doubtless be necessary to wait for the 2004 budget to see the effect of these developments.

Conclusion

A Developing Control Architecture

The risks run by the United States because of dissemination of space imagery will be doubled. There is the threat of use by hostile players for military purposes and the use by the media, which could be politically destabilizing.

The credibility of a military threat is poorly covered, because the countries or organizations likely to make dangerous use of satellite imagery rarely have access to this technology. Most operators up to now are aware of the security motivations of western countries. It could be said that they avoided selling imagery to clients hostile to the US interests in times of international crisis.

The peaceful use by the media and NGOs is a development that is further under way. It asks the question of the effects of increasing circulation of information on management of international and domestic events by US authorities.

The severity of the attacks on American soil in September 2001 is causing leaders to re-tighten controls on any components likely to be detrimental to national interests. To do this, the government decided not to use shutter control, addressed by a directive from 1994, but to enter into a buy out agreement with the only company that can currently bring to market precise images of Afghanistan.

Shutter control threatened to be attacked by the media for not respecting the principle of freedom of the press, contained in the first amendment to the US Constitution. A buy out is a less aggressive measure: Instead of prohibiting the production of imagery, the government buys all of it. The company in question is satisfied with the financial transaction; and the media cannot really denounce the action.

But this new agreement has its limits. First, the media will attack it as much as possible, even if the legal basis for the action is limited now.

Second, this new agreement will underscore the connection between the US intelligence community and the private imagery companies. The financial contribution to the company will not motivate it to develop its private clientele, but will increasingly maintain it in a semi-public status. It can also be asked whether the US government will have the resources to finance such agreements with the other two US companies that are joining the high resolution market. The QuickBird 2 satellite from DigitalGlobe will be operational in February 2002 and NIMA has already announced its intention to enter into a buy out agreement with this company if the international situation warrants it. OrbImage could launch OrbView 3 in 2002.

But the main flaw of the buy out system is in the fact that foreign companies will not necessarily accept it. An agreement could probably be reached with companies in an allied country, such as Spot Image in France. But there are greater uncertainties concerning the position of Indian or Chinese space agencies, which have high resolution systems deployed or projected.

It is to ward off this kind of risk that the anti-satellite arms systems are proposed. The principle of reinforcing military resources in space aimed at the foreign systems, however controversial, seems to have been adopted by the new Administration. Efforts in this area could focus on the development of tactical disruption or interruption resources, representing the least aggressive anti-satellite weapons category

In the spring of 2001, a policy group began to work for the NSC on the means of controlling satellite imagery. The events of September 2001 underscore the importance of this work. The coming months should lead to adjustments in the US control system.

Notes

[1] See the Manuel Castells trilogy on the Information Age: *The Rise of the Network Society* (1996), *The Power of Identity* (1997) and *End of Millenium* (1999), Oxford, Blackwell.
[2] David Brin, *The Transparent Society: Will Technology Force Us to Choose Between Privacy and Freedom?*, Cambridge, Perseus, 1999.
[3] Michel Foucault, *Discipline and Punishment: The Birth of Prison* [*Surveiller et Punir, naissance de la prison*], Paris, Gallimard, 1975.
[4] Bernard Finel and Kristin Lord (eds), *Power and Conflict in the Age of Transparency*, New York, St Martin Press, 2000.
[5] See, for example, Yahya Dehqanzada and Ann Florini, *Secrets for Sale, How Commercial Imagery Will Change the World*, Carnegie Endowment for International Peace, 2000; and John Baker, Kevin O'Connel and Ray Williamson (eds), *Commercial Observation Satellites, at the Leading Edge of Global Transparency*, Rand and ASPRS, May 2001.
[6] *New York Times*, March 26, 2000, p. 1.
[7] John Pike, *Federation of American Scientists*, interview July 22, 1997.
[8] Johnny Skorve and Tomas Ries, *Investigating Kola, a Study of Military Bases Using Satellite Photography*, Norwegian Institute of International Affairs, Brassey's, 1987; Johnny Skorve, *The Kola Satellite Images Atlas, Perspectives on Arms Control and Environmental Protection*, Norwegian Atlantic Committee, 1991.
[9] Other authors having worked on these questions are Bhupendra Jasani and Peter Zimmerman.
[10] Vipin Gupta and Frank Pabian, "Investigating the Allegations of Indian Nuclear Test Preparations in the Rajasthan Desert, a Comprehensive Test-Ban Verification Exercise Using Commercial Satellite Imagery," *Science & Global Security*, vol.6, no. 2, July 1996.
[11] Adams Bernstein and Vipin Gupta, *Keeping an Eye on the Islands, Remote Monitoring in the South China Sea*, Sandia National Laboratory, May 1999.
[12] This term, abandoned by the former Secretary of State, Madeleine Albright, is being used again by the Bush administration.
[13] The State Department is examining applications for export to the following countries: Afghanistan, Angola (UNITA), Armenia, Azerbaijan, Belarus, Burma (Myanmar), China, Cuba, Haiti, Indonesia, India, Iran, Iraq, Lieberia, Libya, North Korea, Pakistan, Rwanda, Serbia-Montenegro, Somalia, Sudan, Syria, Tadjikistan, Ukraine, Vietnam, Zaire.
[14] *Reuters*, March 14, 2001.
[15] Peter Zimmerman, "From the Spot Files, Evidence of Spying," *Bulletin of the Atomic Scientist*, vol. 45, no. 7, September 1989, p. 24.
[16] Peter Zimmerman, "The Use of Civil Remote-Sensing Satellites During and After the 1990-1991 Gulf War," *Verification Report*, VERTIC, 1992, p. 239.
[17] *New York Times*, March 26, 2000, p. 1.
[18] US Senate, Subcommittee on Appropriations, *Foreign Operations, Export Financing and Related Programs Appropriations for Fiscal Year 2001*, April 4, 2000.
[19] <www.fas.org/eye/project.htm>.
[20] Alexander Colhoun, "Top-Secret Kodak Moment in Space Shakes Global Security," *Christian Science Monitor*, March 21, 2000, p.2.
[21] Neil King Jr, "Activists Use Satellite to Challenge View that China's Air Force Menaces Taiwan," *The Wall Street Journal*, May 12, 2000, A20.
[22] Cameron Barr, "Israel's Worst-Kept Secret, on Web," *The Christian Science Monitor*, August 24, 2000, pp. 1 and 7.
[23] During the Gulf War, it was rare for Western press not to support their government. The few images that could be used at the time illustrated information according to that provided by the Coalition staff. The same attitude was seen xuring the Kosovo crisis in March 1999.
[24] Ray Williamson, *Space Policy Institute*, interviews, November 2000.
[25] "Correction," *Newsweek*, August 31, 1998.
[26] Ray Williamson, *Space Policy Institute*, *op.cit*.
[27] "Russian Agency Sells Close-Up Images from Far Away," *New York Times*, June 20, 2000.
[28] The company ImageSat International was called West Indian Space Ltd. until recently.

[29] Vernon Loeb, "US is Relaxing Rules on Sale of Satellite Photos," *Washington Post*, December 16, 2000, p.A3.
[30] The experts from the consulting firm KPGM, quoted by *Defense Daily* on February 10, 1994, estimate that the market should reach 15 billion dollars in annual sales by the end of the 1990s. More conservatively, an estimate from Orbital Science on the same date indicated 5 billion in sales annuality by the end of the 1990s. But in any event, this firm projected having reached the profitability threshold before the end of the 1990s. Finally, for the Department of Commerce, sales in this market, estimated at 400 million dollars for 1994, should reach 2 billion dollars in 2000.
[31] Ron Stearns, aerospace and defense analyst with Frost & Sullivan, interview, February 14, 2001.
[32] Ron Stearns, *op. cit*.
[33] *Commercial Aerial Imaging Data Market, Revenue Forecast, World*, Report 5807, Frost and Sullivan, 2001.
[34] Ron Stearns, aerospace and defense analyst with Frost & Sullivan, *op. cit*.
[35] Joe Dodd, Orbimage, interview, August 24, 2001.
[36] This leads to the assumption that these foreign clients must themselves be intelligence agencies (probably from allied countries), because who else would have the capacity to interpret imagery today?
[37] Joe Dodd, Orbimage, *op. cit*.
[38] Mark Brender, Space Imaging, interview, December 18, 2001.
[39] "(…) Routinely available from foreign commercial sources", "Prohibition on Collection and Release of Detailed Satellite Imagery Relating to Israel," *National Defense Authorization Act for Fiscal Year 1997*, P.L. 104-201, Sec. 1064 (a), Washington, DC, 1996.
[40] *Application to Operate a Commercial Land Observation System*, section B, part 1, US Department of Commerce, National Oceanic and Atmospheric Administration, Washington, DC, March 10, 1994.
[41] Timothy Stryker, NOAA/NESDIS, interview August 29, 2001.
[42] Mark Brender, "Age of Transparency," *Communicator*, September 1995, pp. 164-65.
[43] Dan Dubno, CBS News Producer and Technologist, *Online News Hour*, August 2, 1999.
[44] Michael Gordon, "Pentagon Corners Output of Special Afghan Images," *New York Times*, October 19, 2001, p.B2.
[45] *Ibid*.
[46] The years indicated are the fiscal years, from October to the end of September. *Defense Daily*, September 8, 2000.
[47] Ann Florini, Carnegie Endowment for International Peace, interview February 14, 2001.
[48] Marcia Smith, *Space Launch Vehicles: Government Activities, Commercial Competition, and Satellite Exports*, CRS Issue Brief IB93062, updated version, July 3, 2001.
[49] John Hamre, President of CSIS, August 21, 2001.
[50] Brian Berger and David Pugliese, "Canada Plans to Control Radarsat-2 Data Access," *Space News*, June 21, 1999, p.1.
[51] Steve Cambone was Secretary of the the Commission on the Management and Organization of US Space Agencies (January 2001). He is now Undersecretary of Defense for Policy. Interview November 20, 2000.
[52] ImageSat International already grouped together Israeli companies and an American company. It launched the satellite Eros 1A.
[53] "Principles Relating to Remote Sensing of the Earth from Space," United Nations General Assembly A/RES/41/65, January 22, 1987.
[54] Mark Brender, "Age of Transparency," *op.cit*.
[55] *Statement of Preliminary Policy on Outer Space*, NSC report 5814/1, August 18, 1958.
[56] Laurence Nardon, "American Anti-Satellite Programs," *Le Débat Stratégique*, no. 23, November 1995.
[57] Tom Wilson, "Threats to United States Space Capabilities," *Report of the Commission to Assess United States National Security Space Management and Organization, Appendices: Staff Background Papers*.
[58] Marcia Smith, *U.S. Space Programs: Civilian, Military and Commercial*, CRS Issue Brief IB92011, May 2, 2001.
[59] *Report of the Commission to Assess United States National Security Space Management and Organization*, pursuant to Public Law 106-65, January 11, 2001.
[60] John Logsdon, "Just Say Wait to Space Power," *Issues in Sciences and Technologies*, Spring 2001.

What happens when an information technology moves from being used exclusively by government intelligence agencies to being made widely available? Satellite imagery is now being marketed by companies with space observation systems. What consequences should be feared in particular?

The United States, because of the important role its companies play in developing this market, and because of their great involvement in international affairs, is facing a dilemma: it wants to control this source of information for security reasons, while allowing its companies to become dominant in the new market. How much leeway should it give the image suppliers? What financial support should it provide to the companies?

Very diverse mechanisms for control of satellite imagery have been considered to address the possibility of destabilizing or aggressive use of the imagery. At the beginning of October 2001, the government replaced them on short notice with a very innovative measure. By buying on an exclusive basis all of the satellite photos of Afghanistan taken by the only company that currently produces high-resolution commercial imagery, the Pentagon is preventing other parties from gaining access to this source of information, while providing considerable financial support to the company.

An agreement similar to a buyout will be proposed, and undoubtedly accepted, by US companies entering this market in the future. This kind of action confirms the importance of the connection between the US commercial imagery companies and the federal authorities. It does not settle the question of foreign imagery companies, which will definitely not accept the exclusivity contracts proposed by the US Department of Defense.

This CFE's policy report addresses the U.S. government's response to the current issues in commercial space imagery.

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The French Center on United States (Centre français sur les Etats-Unis, CFE), created in September 1, 1999, at the French Institute for International Relations (Institut français des relations internationales, Ifri), jointly with the Center on the United States and France (CUSF) at the Brookings Institution in Washington D.C., has as its goal the amelioration of the mutual understanding of the public policies of France and the United States. This is to allow their respective leaders to better understand the functioning of the system in the other country, through research on concrete subjects concerning their current relationship.

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