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No more secrets?: Policy implications of commercial remote sensing satellites

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PREFACE

This paper was originally written for the conference on "No More Secrets? Policy Implications of Commercial Remote Sensing Satellites," held at the Carnegie Endowment on May 26, 1999. Sponsored by the Endowment's Project on Transparency, the conference brought together representatives of a score of countries, many U.S. government departments, congressional staff, several nongovernmental organizations, the private sector, and the media for a day-long immersion in the technical and policy issues associated with the emergence of commercial high-resolution satellites. The conference report is available from Ann Florini, director of the Project on Transparency. Highlights of the conference can be seen on the Endowment's web site at www.ceip.org. The Project on Transparency is deeply grateful to the Rockefeller Brothers Fund for its financial support for the conference.

INTRODUCTION

Ever since the earliest satellites and astronauts started taking pictures of the Earth from space nearly four decades ago, those images have inspired excitement, introspection, and, often, fear. Like all information, satellite imagery is in itself neutral. But satellite imagery is a particularly powerful sort of information, showing both comprehensive vistas and surprising detail. Its benefits can be immense—but so can its costs. The same images that remind us that we all share a fragile planet also enable those who have the images to more accurately aim their weapons at adversaries near and far.

And now, the number of people able to use that imagery is exploding. By the turn of the century, new satellites will likely be in orbit with capabilities approaching those of military spy satellites, but with one key difference: the satellite operators plan to do their best to sell that imagery to anyone able and willing to pay. An America-Russian joint venture is already selling imagery that shows objects as small as two meters across (available through the Web at www.terraserver.com). An American company, a Lockheed offshoot called Space Imaging, launched a substantially more sophisticated satellite with one-meter resolution in April 1999. That satellite never reached orbit due to a problem with the launch vehicle, but Space Imaging has a backup satellite nearly ready to go, and a dozen other U.S. companies have licenses to launch high-resolution imaging satellites over the next few years.

The new commercial satellites will make it possible for the buyers of that imagery to, among other things, tell the difference between trucks and tanks, expose movements of large groups like troops or refugees, and pinpoint the probable location of natural resources. Whether all this amounts to a positive or negative development depends on who chooses to use the imagery and how. On the plus side, governments and nongovernmental organizations (NGOs) may find it easier to respond quickly to sudden refugee movements, to document and publicize large-scale humanitarian atrocities, to monitor environmental degradation, or to manage international disputes before they escalate. The United Nations is even looking into the possibility that satellite imagery could help control drug trafficking and narcotics production. But there is no way to guarantee benevolent uses. Governments, corporations, or small groups could use the imagery to conduct industrial espionage, collect intelligence, plan terrorist attacks, or mount offensive military operations. And even when intentions are good, it can be remarkably difficult to know what you are looking at. The media have already made major mistakes, misinterpreting images of everything from Chernobyl in 1986 to the Indian nuclear test site just last year.

Such bloopers notwithstanding, the new satellite imagery will reveal to many people information to which they never before had access. That makes the advent of these satellites both important in itself and a microcosm of a larger trend now sweeping the world—growing transparency. It is becoming more and more difficult to hide information, not only due to technological improvements, but also because of spreading norms about who is entitled to have access to what information. The idea is gaining ground across issue areas and in many parts of the world that governments, corporations, and other concentrations of political and economic power are obliged to provide information about themselves to others. In politics, several countries are enacting or strengthening freedom-of-information laws that provide citizens the right to information on governmental records. In environmental issues, the current hot topic is regulation by revelation, in which polluters are required not to stop polluting but to reveal publicly just how much they are polluting. Such requirements have dramatic effects. Partly to avoid being labeled as big polluters and partly to stop wasting materials they had not previously realized they were wasting, many companies covered by such laws have drastically reduced emissions. In arms control, mutual inspections of sensitive military facilities have become so commonplace that it is easy to forget how revolutionary the idea was a decade or two ago. As democratic norms spread, as civil society grows stronger and more effective in its demands for information around the world, as globalization gives people an ever greater stake in knowing more about what is going on in other parts of the world, and as technology makes such knowledge easier to attain, transparency would appear to be the ineluctable wave of the future.

The legitimacy of remote sensing satellites is part of this global trend toward transparency. Imagery from high-resolution satellites is becoming available now not only because technology has advanced to the point of making the imagery a potential source of substantial profits, but because governmental policies permit, and indeed encourage, such satellites to be operated. Yet as is always the case with increases in transparency, not everyone benefits and not all uses of the resulting information are benign. Governments remain concerned about just how far this new source of transparency should be allowed to go. The provision of information shifts power from the former holders of secrets to the newly informed, which has implications for national sovereignty, for the ability of corporations to keep proprietary information secret, and for the balance of power between state and nonstate actors.

Sovereignty is directly challenged by the new satellite systems. If the satellite operators are permitted to image territory anywhere in the world and sell that imagery to anyone, governments lose a significant degree of control over information about their territory. Although both spy satellites and civilian satellites have been doing this for years, the operators of the spy satellites have been remarkably reticent about the information they have collected, making it relatively easy for countries being imaged to ignore them. Pakistan and India may not like being observed in such detail by the United States and Russia, but as long as the high-resolution satellite operators were not showing information about Pakistan to India and vice versa, objections remained muted. Although the civilian satellites that operated before the 1990s did provide imagery to the public, they had much lower resolution, generally not showing objects smaller than 10 meters across. That low-resolution imagery could provide only very limited militarily significant information, nothing like the information that will be available from the new one-meter systems.

Under international law, countries have no grounds for objecting to being imaged from outer space. The existing standards, the result largely of long-standing U.S. efforts to render legitimate both military reconnaissance and civilian imaging from space, are codified in two UN documents. The Outer Space Treaty of 1967 establishes the notion that outer space cannot be claimed as national territory, legitimating satellite travel in space over any country's territory. And despite years of efforts by then-Soviet bloc and developing countries to claim a right of prior consent in order to review and possibly withhold any data about their territory, in 1986 the UN General Assembly adopting a set of legal principles on civilian remote sensing that make no mention of any right of prior consent. Instead, the principles merely require that "As soon as the primary data and the processed data concerning the territory under its jurisdiction are produced, the sensed State shall have access to them on a nondiscriminatory basis and on reasonable cost terms."

In other words, if a country being imaged knows that it is being imaged and asks for a copy, it is entitled to buy one at the going rate. Even then, countries won't know *who* is asking for specific images, or for what purposes. Does a request for imagery of military bases come from an NGO trying to monitor a country's compliance with some international accord, or from an adversary preparing to strike? There is a major economic concern as well. Corporations may know more about a country's natural resources than the government does, putting governments at a growing disadvantage when negotiating drilling rights or other agreements. And as we have all seen recently, highly visible refugee flows and humanitarian atrocities can attract intense attention from the international community, even while less visible disasters are ignored. The new imagery poses the possibility that the ability of NGOs and the media to track refugee flows or environmental catastrophes will encourage more in the way of international interventions, even over the resistance of the host government. Whether the rather lackadaisical protection of sovereignty contained in the 1986 legal principles will still satisfy governments whose territory is being observed by large numbers of increasingly observant commercial satellites seems questionable.

Governments are not the only ones who may feel an acute new sense of vulnerability. Corporations may find themselves being observed by competitors trying to keep tabs on their construction of new production facilities around the world and estimate the size of their production runs by looking at their emissions. This is not corporate espionage as usually defined, because satellite imaging is thoroughly legal. But it could in time make it quite difficult for corporations to keep their plans and practices secret.

And it will not be only competitors who want to keep an eye on corporations. Environmentalists, for example, may find the new satellites a useful means of monitoring what corporations are doing to the environment. Karen Litfin has pointed out that environmental NGOs already make extensive use of the existing relatively low-resolution imagery that is publicly available to monitor enforcement of the U.S. Endangered Species Act, to document destruction of coral reefs around the world, and to generate plans for ecosystem management.[2]

Environmental groups are just part of a host of nongovernmental organizations likely to take advantage of this new source of information. Some groups that work on security and arms control have already used, and publicized, satellite imagery, such as the Verification Technology and Information Centre in London and the Federation of American Scientists in Washington. As publicly available imagery improves from five-meter to one-meter resolution, humanitarian groups may find it increasingly useful in dealing with complex humanitarian emergencies and tracking refugee flows.[3] In all these cases, nongovernmental groups will find themselves increasingly able to gather and analyze information independently of governments—an important new source of power for civil society.

In short, the emergence of widespread civilian and commercial remote sensing satellites promises both benefits and costs, and thus raises a host of pressing policy questions. Who is regulating them, who should be, and how? Does the new transparency portend an age of peace and stability, or does it create new vulnerabilities that will make the world more rather than less unstable and violent? When should satellite imagery be treated as a public good, to be provided (or controlled) by governments, and when is it a private good to be created by profit-seekers and sold to the highest bidder? Who gets to decide? Is it possible to reconcile the public value of the free flow of information for such pressing purposes as humanitarian relief, environmental protection, and crisis management with the needs of the industry to make a profit by selling that information?

THE POLICY HISTORY

To grapple with these questions, it is important to start with a good understanding of what current policy is, how it came about, and who the players are. Because civilian remote sensing has been so heavily dominated by the United States until quite recently, both in technological and policy terms, much of the story is a U.S. story.

That story begins with the National Aeronautics and Space Administration (NASA), which developed the first civilian remote sensing satellite¾ Landsat. After the launch of Landsat 1 in 1972, the nongovernmental sector got its first glimpse of satellite images of earth. However, Landsat 1's relatively low resolution¾ 80 meters multispectral¾ was too coarse for most commercial purposes. During these early years, research scientists, educators, and government agencies comprised the principal patrons of Landsat imagery.

In an effort to expand the user base for Landsat data and set the stage for the eventual commercialization of the civilian remote sensing industry, the Carter administration issued Presidential Decision Directive (PDD) 54 in July 1979. The PDD transferred the operation of the Landsat systems to the National Oceanic and Atmospheric Administration (NOAA) in the

Department of Commerce and directed NOAA to "seek ways to further private sector opportunities in civil land remote sensing activities … with the goal of eventual operations of these activities by the private sector."[4] The administration hoped that under NOAA the management cost of the Landsat program would decline significantly, thus improving the prospects for its eventual commercialization. Moreover, it was believed that future availability of 30-meter resolution imagery from Landsats 4 and 5¾ planned to be launched within the next five years¾ would dramatically increase the revenue earned from the sale of Landsat imagery.[5] These two factors combined, it was reasoned, would ultimately lead to the creation of an affordable and robust market for remote sensing data, which would encourage the growth of a commercial satellite industry that could develop and operate remote sensing systems for government and private markets.[6]

Following the election of President Ronald Reagan, the Carter administration's gradual approach to commercialization of the Landsat program was abandoned in favor of a far more accelerated plan. In an attempt to cut federal spending by privatizing government programs, the Reagan administration ignored evidence that suggested that the remote sensing market was not sufficiently mature to sustain an independent commercial remote sensing industry. That evidence included four feasibility studies commissioned by the U.S. government between 1982 and 1983. The first study was undertaken by the Civil Operational Remote Sensing Satellite Advisory Committee (CORSSAC) of the Department of Commerce. The study found that the commercial market for Landsat data was seriously underdeveloped and, therefore, recommended that "commercialization of the Landsat program should be done gradually."[7]

The other three studies supported the CORSSAC conclusions. Following an in-depth analysis of the satellite imagery market, ECON Incorporated concluded that "full transfer of the civil land remote sensing system to the private sector, with the expectation of a viable self-sustaining enterprise, is premature."[8] Similarly, Earth Satellite Corporation declared that "No option was found that would permit the [Landsat] program to be commercialized, today or in the near future, without substantial subsidies or government-guaranteed data purchases."[9] Using a much harsher tone, the National Academy of Public Administration argued that the Reagan administration’s decision to transfer operations of the Landsat program to the private sector "fails to meet sensible criteria of preservation of the national security," and represents a "forced premature privatization of these responsibilities."[10]

Despite these cautionary words, the Reagan administration pressed ahead. Faced with the likelihood that funding for the Landsat program would soon be discontinued, Congress quickly approved the *Land Remote Sensing Commercialization Act* (P.L. 98-365), which was signed into law on July 17, 1984. The Act directed the Secretary of Commerce to select a contractor to operate the Landsat system; instructed system operators to market the resulting data on a nondiscriminatory basis; required the Department of Commerce to maintain an archive of land remote sensing data for historical, scientific, and technical purposes; and established a licensing and oversight process for the anticipated private remote sensing industry.

Despite the 1984 Land Remote Sensing Commercialization Act, commercial interest in the remote sensing industry remained limited. In an attempt to jumpstart private initiatives in the remote sensing sector, the U.S. government tried to turn the Landsat program into a moneymaking private venture. Thus, in September 1985, NOAA selected Earth Observation Satellite Company (EOSAT), a joint venture of RCA Corporation and Hughes Aircraft Company, to operate the Landsat satellites and market the resulting data for a period of ten years. According to the terms of the contract, the U.S. government would continue to cover the operational costs of the Landsat program through the three-year expected lifetime of Landsats 4 and 5. In addition, because the market for remote sensing data was considered underdeveloped, the U.S. government agreed to subsidize EOSAT in the amount of $295 million over a five year period to develop and launch two new Landsat spacecraft¾ Landsats 6 and 7. Upon the launch of Landsat 6, EOSAT would assume full responsibility for all operational costs of the Landsat program. Policy makers and EOSAT executives believed—or hoped—that during the lifetime of Landsats 6 and 7, EOSAT's revenues would grow sufficiently to allow the company to finance the development, launch, and operation of future land remote sensing systems.**11**

Responsibility for the operation of the Landsat program was transferred to EOSAT in October 1985. But the government failed to keep its end of the bargain. The Reagan administration deleted additional subsidies to EOSAT in its FY 1987 budget proposal, arguing that the remaining $125 million called for in the EOSAT-NOAA contract would have to come from EOSAT or other private sources. As a result, EOSAT began laying off employees in December 1986 and ceased all marketing and spacecraft development activities. The Congress again intervened in order to ensure the survival of the Landsat program beyond Landsat 5. In FY 1987, Congress appropriated $62.5 million to continue the development of Landsat 6; however, the funds could not be released until NOAA drafted and Congress approved a new Landsat commercialization plan.

In June 1987, NOAA submitted its new commercialization proposal to Congress. It called for only one additional Landsat satellite to be developed by EOSAT as well as a feasibility study for a second satellite that might include more advanced or commercially oriented sensors. Congress initially rejected this proposal, but acquiesced in October 1987. Between November 1987 and April 1988, NOAA renegotiated its contract with EOSAT. The revised contract directed EOSAT to develop Landsat 6 and all associated ground systems. The government agreed to subsidize the project up to $220 million; any additional costs would have to be absorbed by EOSAT. Under an innovative "payback" arrangement, EOSAT also agreed to refund $10.8 million to the government over a period of approximately four years. In addition, EOSAT waived all rights to data from follow-on civil remote sensing spacecraft beyond Landsat 6. With this agreement in place, Congress finally released the $62.5 million appropriated for the development of Landsat 6 in the FY 1987 budget.

As soon as the Landsat 6 development dilemma was resolved, the Landsat program faced yet another crisis. The 1984 Land Remote Sensing Commercialization Act had instructed NOAA to finance the operations of Landsats 4 and 5 through the expected lifetime of the two satellites, which was due to expire at the end of 1987. Consequently, NOAA had no plans to fund either satellite after the expiration date, regardless of whether the satellites were still operational. Thus, NOAA did not request any funds for the Landsat program in its FY1989 budget. Congress quickly appropriated $9.4 million to fund Landsats 4 and 5 for the first half of the fiscal year and asked NOAA to secure funding for the second half. Unable to obtain sufficient funds, NOAA directed EOSAT to turn the satellites off in April 1989. This proposal drew strong protests from the Congress, foreign governments, and data users in the United States and around the world. In response to the outcry, the National Space Council, chaired by Vice President Dan Quayle, drafted an interim funding plan which asked government agencies that used Landsat imagery to provide money to NOAA. Moreover, the National Space Council recommended that the federal government ensure continuity of Landsats 4 and 5 operations so long as these satellites were the only source of civilian remote sensing data.[12] As a result, NOAA rescinded the shutdown order in March 1989.

The same routine played out during the fiscal years 1990 and 1991. In both years, Congress provided $9.5 million for the first six months of the each year and asked other government agencies which utilized Landsat imagery to provide the remaining funds. Finally, on June 1, 1989, President George Bush "approved funding for continued operations of Landsat satellites 4 and 5 and for the completion and launch of Landsat 6."[13] In addition, President Bush "directed the National Space Council and the Office of Management and Budget to review options with the intention of continuing Landsat-type data collections after Landsat 6."[14]

The Undoing of Landsat Commercialization

By the early 1990s, several factors compelled the U.S. government to review the Land Remote Sensing Commercialization Act of 1984. First, the forced commercialization of the Landsat program had faltered badly. Instead of spending $295 million to acquire and deploy two Landsat satellites, the U.S. government had committed itself to spending $245.7 million to develop and launch only one. Moreover, Landsat commercialization had dramatically increased the price of Landsat imagery. As a result, the number of requests for MSS data dropped from 35,272 in 1984 to only 8,000 in 1990.[15] The $4,400 price tag for a single thematic mapper scene deterred many scientists and academics from purchasing Landsat data.

Second, the emergence of foreign competitors to Landsat imagery eliminated the United States' comfortable position as the sole provider of remote sensing data. France successfully launched SPOT-1 in February 1986 and SPOT-2 in January 1990. Both satellites could provide higher resolution images of earth and had a shorter revisit time than the U.S. Landsat system. Although SPOT lacked Landsats' broader swath width and more numerous spectral bands, many in the United States still worried that SPOT would dominate the remote sensing market. This concern gained new urgency as SPOT's sale of remote sensing imagery surpassed that of EOSAT by 1989.[16] Many within and outside the U.S. government began to question the wisdom of a policy that allowed foreign countries to surpass the United States in an industry that was pioneered by the United States

Third, Landsat imagery proved remarkably useful during the planning and execution of the 1990-1991 Persian Gulf War. As D. Brian Gordon of the Defense Intelligence Agency testified, "There were significant contributions by Landsat … to the success of Operation Desert Storm."[17] According to some estimates, the U.S. Department of Defense spent between $5 to $6 million on Landsat imagery during the Gulf War.[18] Throughout the conflict, Landsat imagery was used by allied forces for terrain analysis, operational planning, and concealment detection.[19]

All these pressures led the U.S. Congress to pass the *Land Remote Sensing Policy Act* (P.L. 102-555), which was signed into law by President Bill Clinton on October 28, 1992. The Act recognized that "the continuous collection and utilization of land remote sensing data from space are of major benefit in studying and understanding human impacts on the global environment, in managing the Earth's natural resources, in carrying out national security functions, and in planing and conducting many other activities of scientific, economic, and social importance."[20] The Act further acknowledged that "despite the success and importance of the Landsat system, funding and organizational uncertainties over the past several years have placed its future in doubt and have jeopardized United States leadership in land remote sensing."[21] Therefore, the Act rejected full commercialization of the Landsat program "within the foreseeable future"[22] and transferred control of the Landsat system to the National Aeronautic and Space Administration (NASA) and the Department of Defense (DOD). Authority for licensing private remote sensing satellites was left with the Secretary of Commerce, as it had been under the 1984 Act, with advisory roles given to the Secretaries of State and Defense.

Shortly after the passage of the Land Remote Sensing Policy Act, disagreements arose between NASA and the DOD over what type of sensors should be placed on board the Landsat 7 satellite. NASA favored the cheaper Enhanced Thematic Mapper (ETM) Plus capable of acquiring 15-meter images of earth. DOD, on the other hand, pushed for a new sensor, the High Resolution Multispectral Stereo Imager (HRMSI), which could collect 5-meter-resolution data of particular interest to the Department of Defense. The disagreement had not yet been resolved when disaster struck.

At approximately 11:08 a.m. (PST) on October 5, 1993, nearly 13 minutes after the launch of Landsat 6, a ruptured hydrazine manifold prevented fuel from reaching the satellite engine and the $256.5 million spacecraft plunged into the Pacific Ocean.[23] Following the failure of Landsat 6 to reach orbit, NASA concluded that the high cost of developing the HRMSI sensor could undermine the timely development and deployment of Landsat 7. Thus, in September 1993, NASA officially rejected placement of the HRMSI sensor on board Landsat 7. Consequently, the Department of Defense pulled out of the Landsat program.

With the Department of Defense out, the question of which agency or agencies should develop and operate the Landsat system and market the resulting data once again came to the forefront. This issue was finally resolved by the White House in a Presidential Decision Directive (PDD-3) that was announced on May 10, 1994. According to the PDD, NASA would be responsible for developing and launching Landsat 7, NOAA would operate the spacecraft and all relevant ground systems, and the Department of Interior would archive and distribute the data at the marginal cost of reproduction.

As this paper is being written, however, yet another rearrangement of responsibilities for the Landsat program is underway. A new PDD has been drafted that will transfer all operational responsibility of the Landsat 7 program from NOAA to the Department of Interior's U.S. Geological Survey (USGS). Given that USGS has a more obvious interest in pursuing land remote sensing activities than NOAA, the transfer is expected to be approved in the very near future.

With the successful launch of Landsat 7 on April 15, 1999, the United States came full circle, restoring a significant government subsidy to civilian remote sensing, although now with a substantially improved satellite. Landsat 7 will provide 15-meter panchromatic and 30-meter multispectral images of earth for the next five years. It will have the ability to re-image areas of interest every 16 days with its more accurate ETM Plus sensor. More importantly, Landsat 7 images will be made available to all consumers of satellite imagery "at the cost of fulfilling user requests."[24] At present, these prices are set at $475 per scene for minimally processed data and at $600 per scene for radiometrically and geometrically corrected data¾ over fifty percent cheaper than any other comparable commercially available civilian or private satellite imagery.[25] It is hoped that Landsat 7, launched nearly 30 years after the deployment of the first Landsat spacecraft, will once again place the United States in the forefront of the international civilian remote sensing industry.

The Emergence of a U.S. Commercial Remote Sensing Industry

Although the legal framework for licensing and regulating a commercial remote sensing industry was established in 1984 by the Land Remote Sensing Commercialization Act, no such industry emerged until the early 1990s. In July 1992, shortly before the Land Remote Sensing Policy Act was signed into law, WorldView Inc. applied for a license to operate a commercial satellite capable of achieving three-meter panchromatic images of earth. On January 4, 1993, the National Oceanic and Atmospheric Administration (NOAA) approved WorldView's license. Since then, NOAA has issued twelve more such licenses.

Table 1: Licensed Commercial Systems (1984 - 1999)

Company	Date Applied	Date Approved	System	Web Site
WorldView Inc./Earth Watch	15-Jul-92	04-Jan-93	EarlyBird	www.digitalglobe.com
EOSAT	06-Oct-92	17-Jun-93	Landsat 6	www.spaceimaging.com/
Lockheed/Space Imaging	10-Jun-93	22-Apr-94	IKONOS-1	www.spaceimaging.com/
OrbImage	14-Dec-93	05-May-94	OrbView-1	www.orbimage.com/
OrbImage	14-Dec-93	01-Jul-94	OrbView-2	www.orbimage.com/
Astrovision	26-Mar-94	25-Jan-95	N/A	N/A
EarthWatch/Ball	18-May-94	02-Sep-94	QuickBird	www.digitalglobe.com
GDE Systems Imaging/ Marconi North America	02-Mar-95	14-Jul-95	N/A	www.marconi-is.com/
Motorola	31-Mar-95	14-Jul-95	N/A	N/A
Boeing Commercial Space	19-Jan-96	16-May-96	N/A	www.boeing.com/defense-space/space/
CTA Corporation	06-Sep-96	09-Jan-97	N/A	N/A

RDL Space Corporation	01-Mar-97	16-Jun-98	RADAR-1	www.rdl.com/
Space Technology Development Corporation	11-May-98	26-Mar-99	NEMO	www.spacetechnology.com/

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

This explosion of corporate interest reflects four political and technological changes that have created a newly hospitable environment for private initiatives. First, the collapse of the Soviet Union removed many of the barriers that had stifled private initiatives in the remote sensing sector. Throughout the Cold War, U.S. commercial interests were constantly subordinated to containment of the Soviet threat. As a result, investors were often deterred from developing sensitive dual-use technologies that might be subjected to strict government scrutiny and regulation. Consequently, as Table 1 indicates, between 1984 and 1992, no U.S. firm bothered to apply for a license to operate commercial satellites despite the fact that the legal framework for such ventures was firmly in place.

Second, the belief that over the coming decades the market for remote sensing data would grow exponentially has had a tremendously positive impact on the growth of the private satellite industry within the United States. Despite enormous discrepancies among various estimates of the volume of the remote sensing market in the future, most investors are optimistic that *if they build the systems, the users will come*.**26** The potential future consumers of remote sensing data include farmers, city planners, map makers, environmentalists, emergency response teams, news organizations, surveyors, geologists, mining and oil companies, timber harvesters, and domestic as well as foreign military planners and intelligence organizations.**27** Many of these groups already use satellite imagery provided by French, Russian, and Indian satellites, in addition to Landsat, although none of these satellites matches the capabilities of the new American commercial systems. Hence, this sense of optimism about the future of the remote sensing market coupled with the desire to capture a larger share of that market has driven many companies to invest in commercial satellites and the associated ground systems.

Third, advances in panchromatic, multispectral, and even hyperspectral data acquisition, storage, and processing along with the ability to quickly and efficiently transfer such data files electronically has further supported the growth of the remote sensing industry. As Ray Williamson has noted, "one of the impediments to developing a data market [during the early 1980s] was the absence of a supportive information infrastructure."**28** Since then, the situation changed dramatically. The advent of powerful personal computers capable of handling large data files, the development of geographic information system (GIS) software designed to manipulate spatial data, and the growth of data distribution mechanisms such as CD-ROM disks and the internet have all facilitated marketing and sale of satellite imagery, which has in turn promoted the growth of the remote sensing industry.

Fourth, active U.S. government support has also encouraged the commercial satellite industry within the United States. After Landsat commercialization failed, the U.S. government took steps to promote the growth of an independent commercial satellite industry in the United States.

Concerned that foreign competitors such as France, Russia, and India might dominate the market for satellite imagery, President Clinton issued Presidential Decision Directive (PDD) 23 on March 10, 1994. The PDD, among other things, loosened restrictions on the sale of high resolution satellite imagery to foreign entities.**29** It demonstrated a clear desire by the U.S. government to maintain a strong presence in the international remote sensing market.

The U.S. government has also tried to promote the growth of the U.S. commercial remote sensing industry through direct subsidies to private companies and through guaranteed data purchases. Earth Watch, Space Imaging, and OrbImage, for example, have all been awarded between $2 and $4 million to upgrade their ground systems to facilitate the transfer of imagery data from their satellites to the National Imagery and Mapping Agency (NIMA). In addition, the Air Force has agreed to subsidize OrbImage at up to $30 million to develop and deploy the *Warfighter* sensor capable of acquiring 8-meter hyperspectral images of Earth. Although access to most of *Warfighter*'s higher resolution imagery will be restricted to government agencies, OrbImage will be able to sell 24-meter hyperspectral images to nongovernmental sources. Similarly, the Office of Naval Research has recently concluded an agreement with Space Technology Development Corporation (STDC) whereby the U.S. Navy will provide approximately $60 million to STDC to develop and deploy the NEMO satellite with 30-meter hyperspectral and 5-meter panchromatic sensors. This satellite will not only fulfil the imagery needs of the Navy, but it will also ensure continued U.S. competitiveness in the field of commercial remote sensing.

In addition to direct subsidies to various satellite companies, the U.S. intelligence community has also reached separate agreements with a number of current and future satellite operators to purchase high resolution satellite imagery. Since fiscal year 1998, for example, the National Imagery and Mapping Agency (NIMA) has "spent about $5 [million] annually on commercial imagery."**30** According to Secretary of Defense William Cohen, it is expected that this figure will increase by nearly "800 percent … over the next five years."**31**

Current Policy Choices

The whole history of U.S. policy toward remote sensing has been one of grappling with two difficult tradeoffs: between protection of national security secrets versus promotion of Open Skies as a means of legitimating satellite reconnaissance and civilian remote sensing, and between establishing a commercial industry versus ensuring the public benefits of this unusually comprehensive, and expensive, source of information. To legitimate satellite remote sensing, the United States pushed hard and successfully for international legal principles allowing unimpeded passage of satellites over national territory and for unimpeded distribution of the imagery flowing from civilian satellites. To regain U.S. commercial dominance in the technology, the United States is permitting U.S.-based companies to launch commercial satellites with capabilities substantially better than those available elsewhere. But the United States government, like other governments, hesitates to allow the full flowering of transparency. Now that the public provision of high-resolution satellite imagery is becoming a global phenomenon, policy contradictions are becoming glaringly apparent.

***Unilateral measures*:** The United States is trying to balance its competing interests in satellite imagery in part by a kind of export control with a twist. Unlike other types of dual-use exports, where the point is to keep some physical good within U.S. boundaries, even imagery from U.S.-controlled satellites need never appear within the United States. Satellites make the images in outer space, then transmit them to ground stations, many of which are located in other countries. To maintain some degree of export control in this unusual situation, the United States has come up with a policy called "shutter control." The licenses NOAA has issued for commercial remote sensing satellites contain a provision that "During periods when national security or international obligations and/or foreign policies may be compromised, as defined by the Secretary of Defense or the Secretary of State, respectively, the Secretary of Commerce may, after consultation with the appropriate agency(ies), require the Licensee to limit data collection and/or distribution by the system to the extent necessitated by the given situation."

But shutter control raises some major problems. For one thing, satellite imagery represents a classic case of the difficulty of regulating the "export" of dual-use goods (i.e., those with both civilian and military applications). There are powerful incentives working at cross purposes: economic interest in maintaining a major U.S. presence in what could be a large and highly profitable industry that the United States pioneered, as opposed to national security interest in preventing potential adversaries from using the imagery against the United States or its allies, or even foreign policy interests in not having certain situations publicized. Yet efforts to deny imagery to potential enemies undercut the building of a market for U.S. companies, and may relinquish the field to competitors. After all, imagery "consumers" who know that their access to imagery may be cut off at any time by the vagaries of U.S. foreign policy may well prefer to build commercial relationships with more reliable providers. These difficulties are exacerbated by the fact that the U.S. military itself is increasingly relying on these systems and therefore has a stake in their commercial success. Not only does such imagery provide a useful source of information for U.S. military operations, that information, unlike imagery from U.S. spy satellites, can easily be shared with allies—a considerable advantage in operations like Bosnia or Kosovo.

One extreme form of shutter control is simply to permanently prohibit imaging of a given area. Although such a policy runs counter to long-standing U.S. efforts to legitimate remote sensing, the United States has already instituted one such ban. Under the Kyl-Bingaman Amendment to the 1997 National Defense Authorization Act, U.S. companies are forbidden to collect or sell imagery of the entire country of Israel "unless such imagery is no more detailed or precise than satellite imagery … that is routinely available from commercial sources." The amendment also gives the president the option of extending the blackout to any other country or geographic purpose. When the amendment first passed, it did not seem to raise a significant problem. NOAA reportedly told the American companies at the time that the Russian Spin-2 film imagery at roughly two-meter resolution was equivalent to the U.S. industry's planned one-meter systems. But in July 1998, NOAA informed Earth Watch, Space Imaging, and OrbImage that they would not be allowed to distribute imagery of Israel at one-meter or better resolution. News reports claim that the change in policy came about as the result of intense lobbying by pro-Israeli groups. Given that Israel already operates its own spy satellite (Ofeq-3) and reportedly has plans to enter the commercial remote sensing market itself, allegations persist that Israel is at least as interested in protecting its commercial prospects by hamstringing American competitors as it is in protecting its own security.

Shutter control faces an additional challenge: it may be unconstitutional. The media have already made extensive use of satellite imagery, and some news producers are eagerly anticipating the emergence of the new high-resolution systems. The Radio-Television News Producers Association argues vehemently that the existing standard violates the First Amendment by allowing the government to impose "prior restraint" on the flow of information, with no need to prove imminent national harm to an impartial judge. If shutter control is exercised in any but the most compelling circumstances, a court challenge is inevitable.

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

An alternative is to try to get other operators of high-resolution satellites to agree to restrict the collection or dissemination of imagery. Is there scope for negotiation of some kind of agreed restraints? Canada, for example, plans to launch a new radar satellite with three-meter resolution. Initially, NASA was to launch the satellite but expressed reservations once it became clear just how good the resolution on the satellite would be. Whether it will be possible for the two countries to come to an understanding on how the distribution of the imagery should be restricted remains to be seen, and there is not much reason to believe that Russians, Chinese, or Indians would respect U.S. wishes on what imagery should be disseminated or to whom.

If it proves unworkable in the long run to control the flow of information from satellites, either unilaterally or by agreement with other countries, two options remain: taking direct action to prevent the satellites from seeing what they would otherwise see, or learning to live with the new transparency. Direct action can take two forms: hiding what is on the ground, or disabling the satellites in the sky.

Satellites generally travel in fixed orbits, making it easy to predict when one will be overhead and thus when it is necessary to take concealment measures. Hiding things from satellite observation is an old Cold War trick. The Soviets used to deploy large numbers of fake tanks and even ships. Sensitive objects can be covered with conductive material such as chickenwire screening to create a reflective glare that obscures the details of whatever is underneath. Indeed, one of the security concerns for the United States is whether countries that currently do not bother with trying to conceal their activities from U.S. spy satellites will institute concealment measures once they become aware that commercial operators may sell imagery of them to regional adversaries or others. In other words, the advent of commercial high-resolution satellite imagery may cause the United States to lose access to information it currently has from its spy satellites.

Although concealment is often possible, it will become harder as the number of eyes in the sky proliferates, reducing the windows in which to carry out activities unobserved. Moreover, the new systems have the ability to look from side to side as well as straight down, so knowing what the satellite is observing is not so easy.

If hiding does not work, what about countermeasures against the satellite? There are many ways other than shooting them down to put satellites out of commission, especially unprotected civilian systems that are of necessity in low Earth orbit.[32] Electronic and electro-optical countermeasures can be used to jam or deceive a satellite. Satellites can be spoofed—interfered with electronically and made to shut down or change orbit. The operator may never know whether a malfunction is merely a technical glitch or the result of a hostile action. (And the spoofer may never know whether the target satellite was successfully affected.)

Such countermeasures could be very useful during crises or war to prevent access to imagery of a specific, temporary activity without the legal bother of shutter control or the political hassle of negotiated restraints. But during peacetime, they would become rather obvious if carried out on a routine basis to prevent imaging of a particular site.

The more dramatic approach would simply be to shoot the satellites down. Short of a situation of imminent or actual war, it is hard to imagine that the United States would want to do this, even to satellites operated by nationals of other countries and thus not subject to shutter control. If the United States could live with Soviet spy satellites, it is hard to see that it would casually bring down international opprobrium on itself by destroying civilian satellites. And in wartime, the operators with the greatest satellite capabilities may well be U.S. companies or U.S. allies. Other countries might be able to shoot down satellites, but such an act would carry a heavy risk of starting a war. And because so many satellites will be operating within the next few years, it is virtually unthinkable that even the most paranoid government would be able and willing to bear the military and political costs of shooting them all down.

CONCLUSION

No one is fully prepared for the era of commercial high-resolution satellite imagery. The U.S. government is trying to maintain a kind of export control over a technology that has long since proliferated beyond U.S. borders. The international community as a whole agreed over a decade ago to permit the unimpeded flow of information from imagery, an agreement that may come under considerable strain as new and far more capable satellites begin to distribute imagery publicly and widely. Humanitarian, environmental, and arms control NGOs could put the imagery to good use, if they can acquire sufficient funds and the necessary expertise, but governments may be uncomfortable with the resulting shift in power from state to nonstate actors—especially if those nonstate actors include terrorists. And many, many people will make mistakes, especially in the early days. Satellite imagery is hard to interpret. Junior analysts are wrong far more often than they are right.

Despite all the potential problems, on balance this new form of transparency is likely to do more good than harm. It will allow countries that might otherwise live in fear and suspicion of one another to provide credible reassurance that they are not mobilizing for attack. It will help both governments and nonstate actors to cope with the growing number of global problems by facilitating the creation of comprehensive sources of information that no single government has an incentive to provide. Although imagery is subject to misuse and misinterpretation like any source of information, the circumstances under which sustained secrecy works to the public benefit are few.

ENDNOTES

1. New environmental applications of satellite imagery are not quite as immediate as are some of the security concerns, because one-meter spatial resolution does not provide a significant advance over the existing systems for environmental purposes. Environmental applications will become far more significant when hyperspectral systems become available. That is not far off, however. The Orbview 4 satellite, due to be launched next year, will carry a hyperspectral sensor.
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5. "Remote Sensing and the Private Sector: Issues for Discussion." United States Congress, Office of Technology Assessment. Washington, DC. March 1984; p. 62.
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19. Kutyna, Donald J. Prepared Statement. Hearings before the U.S. Senate Armed Services Committee. April 23, 1991; p. 733. And Gordon, D. Brian. Testimony before the U.S. Congress Committee on Science, Space and Technology and the Permanent Select Committee on Intelligence. June 26, 1991; p. 29.
20. "Land Remote Sensing Policy Act of 1992." Section 2(1). Washington, DC. October 28, 1992.
21. Ibid, Section 2(7).
22. Ibid, Section 2(6).
23. "Landsat 6 Failure Attributed to Ruptured Manifold." Department of Commerce, National Oceanic and Atmospheric Administration. March 10, 1995. The price includes all costs born by the U.S. government as well as EOSAT to develop and launch Landsat 6.
24. "Land Remote Sensing Policy Act of 1992." Section 2(13). Washington, DC. October 28, 1992.
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26. Estimates of the volume of the market for remote sensing data range from $2 billion to $20 billion by the turn of the century. See Gabbard, C. Bryan and Kevin M. O'Connell. "Emerging Markets of the Information Age: A Case Study in Remote Sensing Data and Technology." RAND (1996); p. 18.
27. Statement by the Press Secretary. The White House, Office of the Press Secretary. Washington, DC. March 10, 1994; p. 1.
28. Williamson, Ray A. "The Landsat Legacy: Remote Sensing Policy and the Development of Commercial Remote Sensing." *Photogrammetric Engineering & Remote Sensing*. Vol. 63, No. 7 (July 1997); p. 883.
29. Statement by the Press Secretary. The White House, Office of the Press Secretary. March 10, 1994; p. 1.
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31. Cohen, William. Remarks to the Opening Ceremonies of the National Space Symposium. Colorado Springs, CO. April 5, 1999, p. 1.
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