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Introduction

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Commercial observation satellites are emblematic of information age technologies at the start of the new millennium; they promise to bolster global transparency by offering unprecedented access to accurate and timely information on important developments. Uninhibited by political borders, these earth-orbiting satellites collect images of human activities and the natural environment, images that will be available globally on a commercial basis. A broad range of government agencies and nonstate actors, including international organizations, the news media, businesses, and nongovernmental organizations (NGOs), will gain access to satellite images of sharpness and quality previously available only from U.S., Russian, and French military reconnaissance satellites. Even individuals and small groups will be able to purchase images off the Internet. For the most part, the imagery data produced by earth-observation satellites will provide information to meet wide-ranging civil and commercial remote sensing needs, such as surveying natural resources, monitoring the health of crops and vegetation, and supporting humanitarian and disaster relief operations.

However, commercial earth-observation satellites are also a dual-use technology with important national-security applications because they feature major improvements over the earlier civilian satellites in image sharpness (feature resolution) and timely delivery of imagery data. Higher-resolution

images can help warn countries of military buildups by threatening neighbors and can support negotiations to settle their territorial disputes. Hence, diplomats, military planners, and intelligence analysts around the world are likely to welcome commercial observation satellites as an important new source of information.

Unfortunately, not all earth-observation data purchasers have benign intentions. Some governments will undoubtedly use satellite images for aggressive purposes against other countries or even against groups within their own countries. And worrisome nonstate actors, such as terrorists and narco-criminal groups, could learn to use satellite images for their own harmful purposes. Thus, the dual-use nature of commercial earth-observation satellites poses major policy issues for the United States and other national governments that support and regulate these new imaging satellites.

Governments will also play an important role in determining the economic prospects for commercial observation satellites. To succeed, the new commercial earth-observation enterprises must make the transition from being primarily providers of satellite imagery data to offering geospatial information products and services tailored to a broad range of traditional and new customers. A successful transition would secure them an integral role in the knowledge-based economy. National governments, as both regulators of commercial observation satellites and major customers for imagery products, will exert a crucial influence on how the emerging global market for earth-observation data and information products develops.

The U.S. experience to date highlights the challenges of designing and implementing policies that regulate commercial observation satellites in ways that both promote this fledgling industry and safeguard national-security interests, while also addressing the concerns of other countries. U.S. and foreign policymakers now face a series of difficult choices: how best to deal with the dual-use nature of high-resolution imagery, how to balance public needs and private interests in producing and consuming earth-observation data, how to redefine the relationship between governments and various nonstate actors in using satellite imagery, and how to reconcile the need for international cooperation with the inevitable pressures arising from commercial competition.

This book assembles a multidisciplinary group of policy analysts and experts in different imagery applications to offer the reader a broad perspective on the political, security, and market implications of commercial earth-observation satellites. Each chapter is written to reach nonspecialists while still

offering insights on emerging issues of concern to policymakers and commercial practitioners. The chapters are grouped into the following main parts:

- **Section I: The Policymaking Context** provides essential historical background and an overview of the major policy issues and technical trends associated with commercial and civilian observation satellites. Chapters in this section explore the broader issues that growing access to satellite imagery, which significantly contributes to global transparency, poses for policymakers.
- **Section II: National Remote Sensing Programs and Policies** relies on both U.S. and foreign experts to provide readers with a detailed assessment of U.S. and selected non-U.S. commercial and civilian remote sensing programs. This section includes chapters devoted to countries that possess mature earth-observation satellite programs (i.e., the United States, Russia, France, and Japan), as well as other countries with rapidly emerging programs (i.e., India, Canada, and Israel).
- **Section III: Case Studies in Remote Sensing Applications** offers in-depth assessments by remote sensing experts that demonstrate the potential benefits and limitations of the new commercial and civil government satellite imagery for helping policymakers and experts. The case studies address a range of international security problems, including resolving territorial disputes, monitoring nuclear proliferation, supporting humanitarian relief activities, and formulating a regional cooperative monitoring regime.
- **Section IV: Emerging International Policy Issues** focuses on the salient policy issues created by rapidly expanding global and public access to higher-resolution satellite imagery. This section highlights the distinctive interests of and roles played by national governments, NGOs, and the news media. It also addresses the broader international politics surrounding commercial observation satellites.

Advent of Commercial Observation Satellites

In the first years of the new millennium, the users of satellite imagery can look forward to having access to the data from more than two or three dozen civil and commercial observation satellites, offering a range of image types and resolutions (see Appendix A). These new satellites continue a trend that began in 1972 when the United States launched the world's first civilian remote sensing satellite, Landsat.¹ This pioneering satellite collected digital multispectral

(i.e., color) images at about 80-m resolution.² Images at this resolution are sufficient for routinely monitoring natural features and broad human influences on the earth's surface, such as urbanization, but much too coarse for identifying details, such as vehicles or even individual buildings. In comparison, the new generation of commercial and civilian earth-observation satellites is capable of collecting images at much higher resolutions. For example, the world's first truly commercial earth-observation satellite, Space Imaging's IKONOS, successfully launched in September 1999, collects panchromatic (black and white) images with better than 1-m resolution, which, under the right conditions of lighting and contrast, is sufficient to detect objects as small as the average card table. The IKONOS satellite can also collect multispectral images at about 4-m resolution.

A clear distinction originally existed between civilian remote sensing satellites, such as Landsat, and the imaging satellites the United States and Soviet Union relied on for military reconnaissance and intelligence-gathering purposes, such as the U.S. CORONA military reconnaissance satellite system. The civilian satellites mainly focused on acquiring lower resolution, multispectral imagery that was better suited to scientific and civil needs; the military satellites mostly collected high-resolution panchromatic images to monitor worldwide military developments and strategic events. Military users attached high priority to the timely acquisition and processing of satellite imagery data to satisfy their need for adequate warning of any enemy attack or for supporting policymakers involved in foreign policy crises. In comparison, civilian users were more willing to wait weeks and even months to receive high-quality imagery quality at low cost, even if timeliness was sacrificed. It is important to note that governments, throughout the Cold War, treated military images as highly classified national-security information and never released them publicly. In contrast, civilian satellite imagery data, which are largely governed by a scientific ethos, have been openly published and globally shared with relatively few restrictions.³

Commercial earth-observation satellites now blur such long-standing differences between civil and military imaging satellites. These new satellites are being financed, built, and operated by private firms seeking to create profitable businesses by selling satellite imagery and services. They also see these data as invaluable inputs for a broad range of geospatial information products that various commercial and government customers desire.

Similarly, the distinction between civilian (government-owned) and commercial (government licensed but privately owned) observation satellites is

becoming less clear cut. Civilian earth-observation enterprises in Europe, Canada, and Russia are increasingly focused on selling data in the commercial satellite imagery market to help cover their operating costs. In comparison, U.S. commercial remote sensing firms are looking to U.S. government agencies as some of their more important customers for imagery products and services. Thus, much of this book's discussion on commercial earth-observation satellites will also apply to their civilian counterparts.

A confluence of trends—political, technological, and economic—has encouraged firms to enter the nascent earth-observation data marketplace some 40 years after the first Sputnik satellite achieved orbit. The primary inhibiting factor was not technology barriers but policy constraints. The end of the U.S.-Soviet confrontation had the effect of relaxing earlier Cold War restrictions on satellite imaging technologies and expanding public access to higher-resolution images. By the early 1990s, Moscow was allowing the sale of declassified imagery (with resolutions as sharp as 2 m) from Russian military satellites in the international marketplace. Washington soon responded to avoid placing U.S. industry at a disadvantage in the emerging global market. Building on earlier legislation, the 1992 Land Remote Sensing Policy Act set forth provisions for licensing commercial earth-observation satellites. The first such license (for WorldView's 3-m resolution satellite⁴) was issued in January 1993, in the last days of the Bush administration. Because of their national-security implications, license applications for satellites of much higher resolution challenged the U.S. policy process. However, with strong encouragement from industry and Congress, the Clinton administration issued Presidential Decision Directive (PDD) 23 in March 1994, which set specific regulatory guidelines for U.S. commercial remote sensing enterprises. These licenses permit U.S. firms to sell high-resolution satellite imagery and to seek government approval for selling remote sensing technologies or even turnkey imaging satellite systems to foreign buyers. Less than a year later, the U.S. government also announced its decision to declassify over 800,000 CORONA spy satellite images that had been acquired between 1960 and 1972.

Technology push also spurred greater industry interest in developing commercial observation satellites and marketing imagery products. Advances in satellite and optical sensor technologies allow the development of imaging satellites that are substantially smaller, cheaper, and more agile than the relatively large and expensive Landsat and other civilian observation satellites. Both types of imaging satellites could produce higher-resolution panchromatic

(i.e., black and white) and multispectral (i.e., color) images. And some firms hope to develop commercial customers for other types of imaging technologies, such as radar and hyperspectral sensors.

Equally important has been a rapid improvement in enabling technologies that reduce the technical and cost barriers for a potentially broader range of customers in using satellite imagery. These technologies include more-affordable computing power, user-friendly software for processing and displaying satellite images, and less-expensive data-storage systems. Furthermore, commercial remote sensing firms have been quick to take advantage of the Internet for permitting potential customers to search and order satellite images from their large and growing imagery databases.

The political and technological trends for commercial earth-observation satellites are generally encouraging. However, the contribution of commercial observation satellites to global transparency also depends on their economic prospects, and the commercial viability of the remote sensing firms is far from certain at this early stage. Convinced that a potentially strong domestic and international marketplace exists for satellite imagery data and information products, several U.S. firms invested heavily in the first generation of commercial observation satellites. They lead the way in creating the necessary ground infrastructure and sophisticated imagery archives and in creating the multinational partnerships needed to break into the global marketplace. Their actions provided added impetus for non-U.S. remote sensing enterprises to explore their own options for becoming more engaged in the international market for earth-observation data. A key question, however, is whether firms that have substantial experience in building and operating the earth-observation satellite systems can reinvent themselves to be highly competitive in the emerging information economy, with its growing emphasis on e-commerce as a model for information products and services.

Global Transparency and Commercial Observation Satellites

One of the new millennium's defining features is rapidly growing global transparency. This trend is driven by a combination of factors, including more-open political and economic institutions, rising expectations about public access to information, and an explosion of information technologies. Key technologies include global telecommunication networks, the Internet and World Wide Web, commercial and civil observation satellites, and other enabling technologies that encourage worldwide connectivity and awareness. Commercial observation

satellites are playing a leading role in expanding transparency on a global basis because they offer a broad range of actors (e.g., governments, corporations, the news media, NGOs, and even individuals) an unprecedented ability to acquire relevant information on natural and human developments occurring nearly anywhere in the world.

Earth-observation satellites uniquely offer global coverage as they operate beyond the limits of national sovereignty.⁵ Most other information sources are constrained by borders or are scarcely found in remote regions and war zones. Space-based observation systems can also penetrate denied areas to obtain invaluable information where authoritarian regimes, or internal conflicts, substantially limit the amount of information available to the outside world. For example, these data can be used to reveal environmental disasters, detect mass graves, and identify questionable activities occurring at nuclear facilities and military sites—despite the efforts of host governments or warring factions to restrict external access to the territory they control. Even if some facilities are placed underground or concealed by other measures, indications of their existence and activities are likely to appear on satellite imagery over time.

In the past, Landsat and SPOT earth-observation satellites captured public attention when they returned images in 1986 that revealed the extent of the Chernobyl nuclear reactor disaster, despite the stonewalling of Soviet officials at the time. Such satellites have also provided convincing evidence on the disturbing rate of deforestation in the Amazon and other tropical forests and the effects of oil pollution along coastal areas. In comparison, commercial observation satellites will offer higher-resolution, stereo capabilities, and the relatively rapid delivery of imagery data. Furthermore, as a result of commercial marketing, imagery data will be substantially more accessible to a broad range of countries and nonstate actors.

Thus, these new imaging satellites could bolster global transparency by collecting timely images that focus international attention on war preparations among regional adversaries or provide timely data to assess the nature of humanitarian emergencies occurring around the world. The contribution to global transparency does not depend on a single satellite but arises from the cumulative impact of a growing constellation of commercial and civilian observation satellites that are slated to become operational over the next few years (see Appendix A). International access to a large number of observation satellites using various types of imaging sensors (e.g., electro-optical, radar, thermal) will substantially enhance global transparency by increasing

the chances that major events occurring around the world will be captured on overhead imagery in a timely fashion.

The new commercial earth-observation satellites also raise important questions on the policymaking relationship between governments and non-state actors. Private and nongovernmental actors with a strong interest in using satellite imagery for public policy purposes include the news media and a broad range of NGOs concerned with public policy issues, including arms control and nonproliferation experts, environmental groups, and international NGOs concerned with human rights and humanitarian relief activities, all of whom could use satellite imagery to advance their agendas. These new “imagery activists” will use information derived from satellite images for independent assessments that can either confirm or challenge the accuracy of government assessments. Debates over imagery credibility could arise in specific cases as these new users, who have relatively limited experience in image interpretation, build their proficiency in analyzing satellite imagery data.

The expert contributors to this book generally agree that global transparency is inevitable, but they pointedly disagree on whether this trend will increase or diminish international security. Many of the chapter authors share the view that—on balance—global transparency, and commercial observation satellites in particular, will enhance international security. This view holds that a security benefit will arise from having expanded access to earth-observation satellites that can help anticipate and document when countries are engaging in aggressive behavior or when governments are undertaking large-scale internal atrocities. However, an alternative perspective contends that greater transparency may actually erode the national security of countries located in regions where the risk of war is high by diminishing the uncertainties that help dissuade military conflicts. To some degree, these alternative perspectives on the broader security implications of global transparency help to frame the debate over the dual-use nature of commercial satellite imagery.

Dual-Use Aspects of Commercial Observation Satellites

As noted earlier, commercial earth-observation satellites are intrinsically a dual-use technology. Their military potential will only grow as more commercial observation satellites become operational. The 1990–1991 Gulf War highlighted the growing importance of civilian observation satellites to military activities. The United States and its Coalition allies benefited from Landsat and SPOT imagery data that were used to support various military missions

and to provide a way of sharing imagery data among all partners. At the same time, steps were taken to deny Iraqi forces access to the same imagery sources during the Desert Shield and Desert Storm operations, as well as imagery from U.S. and European weather satellites. The Gulf War experience encouraged several countries to seek to acquire their own observation satellite systems or to gain access to commercial observation satellites. Although a few countries, such as the United States, Russia, and France, have their own military reconnaissance satellites, most countries do not. Thus, the military and intelligence establishments of many countries will probably take advantage of commercial observation satellites as a new source of overhead information.

Along with their potential military applications, commercial and civilian observation satellites offer a new instrument for supporting peace negotiations and encouraging regional conflict resolution. Civilian satellite imagery and three-dimensional visualization technologies helped the U.S. negotiators at the 1995 Dayton peace talks resolve complicated territorial issues that were obstructing the final peace settlement for Bosnia. Similarly, the United States provided civilian imagery and mapping support to facilitate the successful negotiations that ended the long-standing border dispute between Ecuador and Peru. These cases suggest that opportunities could exist for creating cooperative monitoring regimes using commercial observation satellites to reduce the potential risk of regional conflicts arising over geographical flashpoints elsewhere in the world.

Thus, policymakers face a new challenge in taking advantage of the benefits commercial observation satellites promise while limiting the potentially harmful uses that can be made of their data. Any attempt to restrict the use of commercial satellite imagery for military and intelligence purposes will be complicated by the difficulty of separating potentially aggressive uses of imagery data from legitimate defensive needs for timely information on activities occurring beyond a state's boundaries. More specifically, any interest the U.S. government may have in using administrative measures to prevent U.S. commercial earth-observation satellite companies from collecting or selling imagery because of military or foreign policy raises contentious constitutional issues involving first amendment rights.

Uncertain Markets and Competing Government Policies

Although the political and technological trends are generally encouraging for commercial observation satellites, greater uncertainty surrounds the economic

prospects. The perception that most countries are shifting to knowledge-based economies only encourages the notion of a rapidly growing international market for satellite imagery and information products over the next few years. Nonetheless, commercial imaging satellite firms confront stiff competition in selling geospatial information products and services at home and abroad. Aerial photography firms have long dominated the remote sensing market and are pursuing their own innovative paths in the data marketplace. Land-based surveys using Global Positioning System (GPS) data and geographic information systems (GIS) both complement and compete with satellite imagery in providing affordable geospatial information.

At the same time, international competition in providing geospatial information products and services is likely to be fierce, particularly because many civilian observation satellites are also focused on establishing a niche in the emerging global market for satellite imagery, even though they are usually state-owned or rely on substantial government subsidies. Furthermore, international interest in acquiring imaging satellites is steadily growing as countries such as Australia, Brazil, Israel, South Korea, and Taiwan make progress in developing or purchasing their own civilian and commercial observation satellites.

National governments will be critical to the long-term success of the commercial observation satellites. Governments can play multiple and concurrent roles because they serve as regulators, patrons, customers, and even competitors in some cases. On the positive side, government policies and programs can promote the beneficial contributions of commercial observation satellites while limiting the chances that their imagery data will be used for harmful or aggressive purposes. Yet governments can also inhibit the development of the fledgling commercial remote sensing industry. Government policies can unintentionally undercut the commercial viability of startup firms through excessive regulations. Struggling private firms can also become too dependent on government sales rather than taking the hard and risky efforts needed to develop the commercial market for satellite imagery products and services. Thus, national governments must reconcile competing policy objectives in dealing with commercial remote sensing enterprises.

This book offers an in-depth assessment of the policy implications of a new information technology—commercial observation satellites—that is coming of age at the start of the new millennium. The various chapters suggest that these imaging satellites can enhance global transparency, encourage economic development, and contribute to international security. However, the

book contributors also recognize that commercial satellite imagery can be put to more harmful uses. Thus, the primary challenge is to find ways of hedging against the potential risks that unprecedented global access to overhead imagery poses without diminishing the many positive contributions that commercial observation satellites can offer for civil, commercial, and international uses.

Notes

- 1 Landsat 1 was originally named the Earth Resources Technology Satellite (ERTS-1).
- 2 *Resolution* generally refers to the size of the smallest object that can be distinguished in an image from its surroundings. Higher-resolution images (e.g., 1 m) enable imagery analysts to detect and identify smaller objects, such as vehicles and small buildings, whereas lower-resolution images (e.g., 20 m or larger) are mainly limited to distinguishing such objects as airports, population centers, and large natural features.
- 3 With the exception of imagery data gathered by U.S. government satellites, most of these data are protected by copyright and use-related licensing provisions.
- 4 Unfortunately, that satellite failed in orbit a few days after its launch in December 1997.
- 5 National sovereignty extends only to the airspace above a state. The 1967 Outer Space Treaty guarantees the right of all states to use outer space for peaceful purposes. However, cloud cover and dark of night significantly limit the use of optical sensors. Certain regions at certain times of year are particularly difficult to image from space because of darkness or cloud cover. Radar, on the other hand, can pierce both cloud cover and darkness. Furthermore, given their orbital dynamics, imaging satellites are only occasionally in the right overhead position.